consulting engineer

OF MICHIGAN
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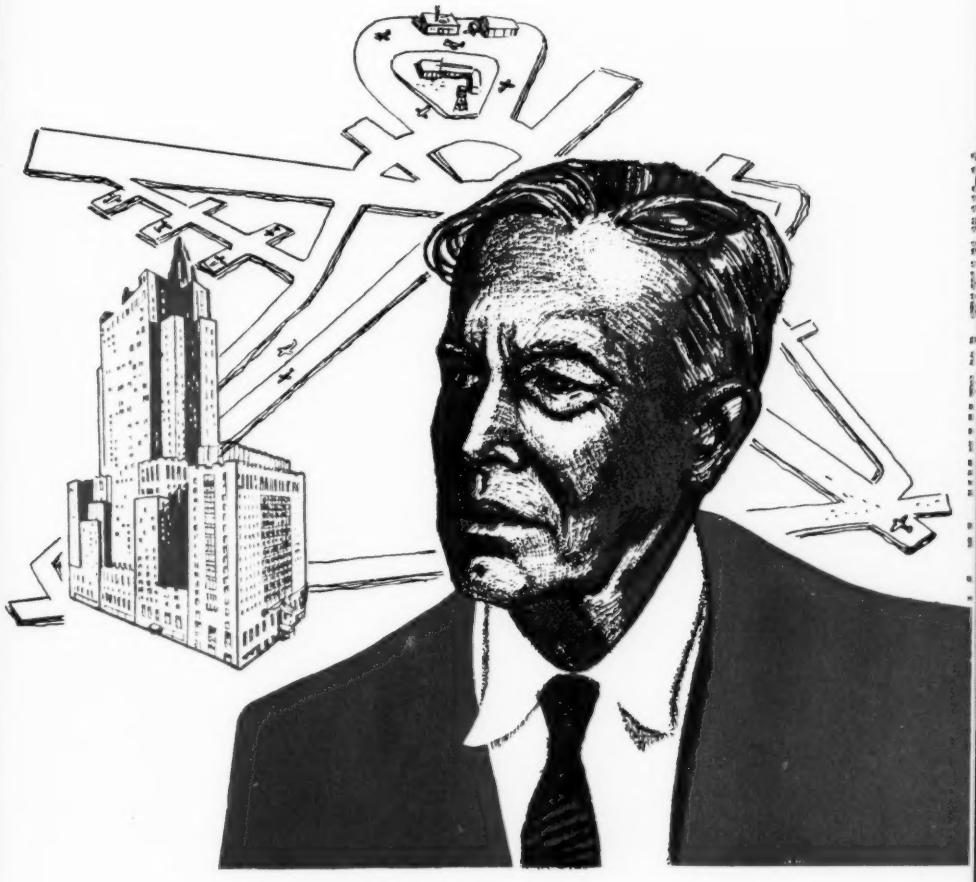
SPECIAL REPORT
— Free Piston Engines
Underground Gasification of Coal
Legislation to Attract Industry
Light-Duty Overhead Networks
Understanding Explosions
Technique of Pressure Control
The Surface and Below

August 1953



. . . just back from the Arctic Circle

Bottom-of-the-Caisson Man

ELWYN E. SEELYE heads the partnership of Seelye, Stevenson, Value and Knecht, with offices near New York's Grand Central Terminal — a building on which he worked as an assistant engineer shortly after his graduation from Cornell University. Over the years, he and his engineering firm have handled assignments ranging from historic edifices

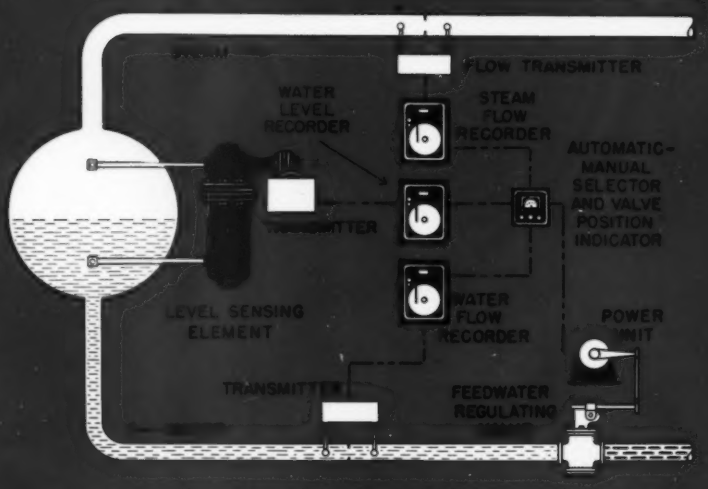
(Continued on page 8)

CONSULTATION • DESIGN • CONSTRUCTION

a new electronic feedwater control!

electronic null balance remote operation

control operative even on cold boilers



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MICHIGAN CITY 32, INDIANA

VOLUME 2
NUMBER 6

consulting engineer®

AUGUST 1953

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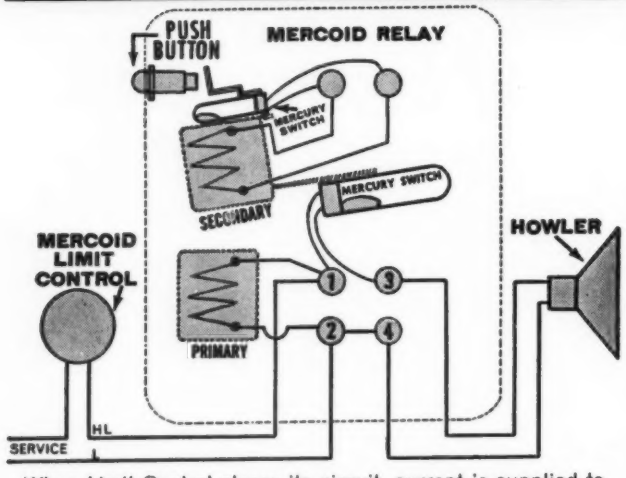
MERCOID RELAY FOR AUDIBLE ALARM



When Limit Control closes its circuit, current is supplied to primary coil of Mercoid Relay and through the normally closed mercury switch to the "Howler" (alarm). To stop "Howler," operator pushes in "push button" which manually raises relay secondary and breaks circuit to "Howler." Secondary is held up by magnetic repulsion until condition is corrected. When limit control opens the primary circuit of relay, secondary coil drops to normal position and relay is automatically ready for another operation.

WRITE FOR BULLETIN CA-8R

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Very truly yours

"HOW CAN YOU HOPE to cover the consulting field sufficiently to interest men in the various divisions of the profession?" is a question which was asked us recently by an editor of a magazine in the power field, who had just seen CE for the first time. This editor went on to say, "For example I know one man who is a consultant on production problems of milk plants and nothing else." Our editor, Hunter Hughes, gave him an answer which shows specifically how we aim to make every issue of interest and help to each reader.

Here's an extract from Hughes' letter: "We do, of course, have a problem in giving complete coverage for all our readers, which is a problem common to all horizontal-coverage magazines. However, I believe our problem is less serious than many other magazines because consultants, regardless of their type or field, share a great number of problems. For example, your consultant friend, who deals only with problems of milk plants, still has the questions of office operation, fees and contracts, relations between consultant and employer, and he would no doubt also be interested in such general technical fields as metals and corrosion, new synthetics, and fluid flow. I could also feature his being interested in refrigeration, drying methods, and transportation. Certainly he is interested in management and engineering economics. Of course, we cannot carry a story on milk plants, but there are so many problems connected with milk plants which apply to all industry that I believe we can make him happy from issue to issue."

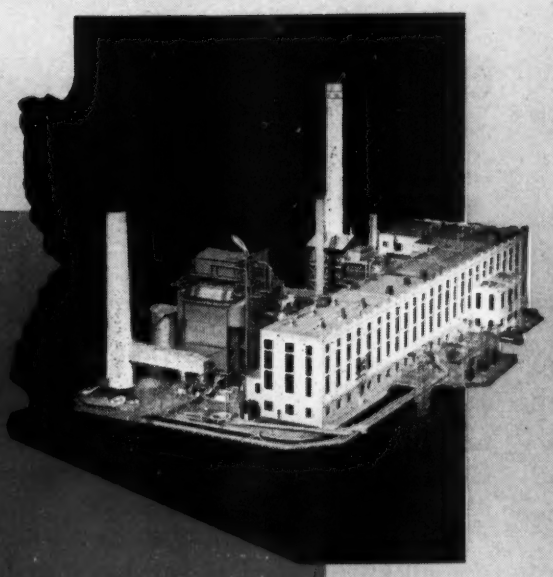
It's always well to remember the little wise crack that William Allen White once published in his famous *Gazette*. He said, "... went over to the county poorhouse the other day to see Jim Thompson, who used to publish a newspaper that tried to please everybody." But ... if a magazine can be edited to please all its readers and still stay out of the poorhouse, our staff can do it, and I don't feel a bit uneasy letting my chips ride with them.

Very truly yours,

M J Sanders

Publisher

ALSO IN ARIZONA, IT'S YARWAY



PUBLIC SERVICE

PICKS

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FOR 920 PSI BLOW-DOWN SERVICE

Arizona Public Service Company—operating in the youngest, but one of our fastest-growing states—is another prominent utility that relies on Yarway Unit Tandem Blow-Off Valves to guard its boilers. In fact, *4 out of every 5 high pressure boiler plants are Yarway-equipped.*

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Yarway engineers, conveniently located near you, are constantly working for better, more profitable steam plant operation. Need help? Call a Yarway man.

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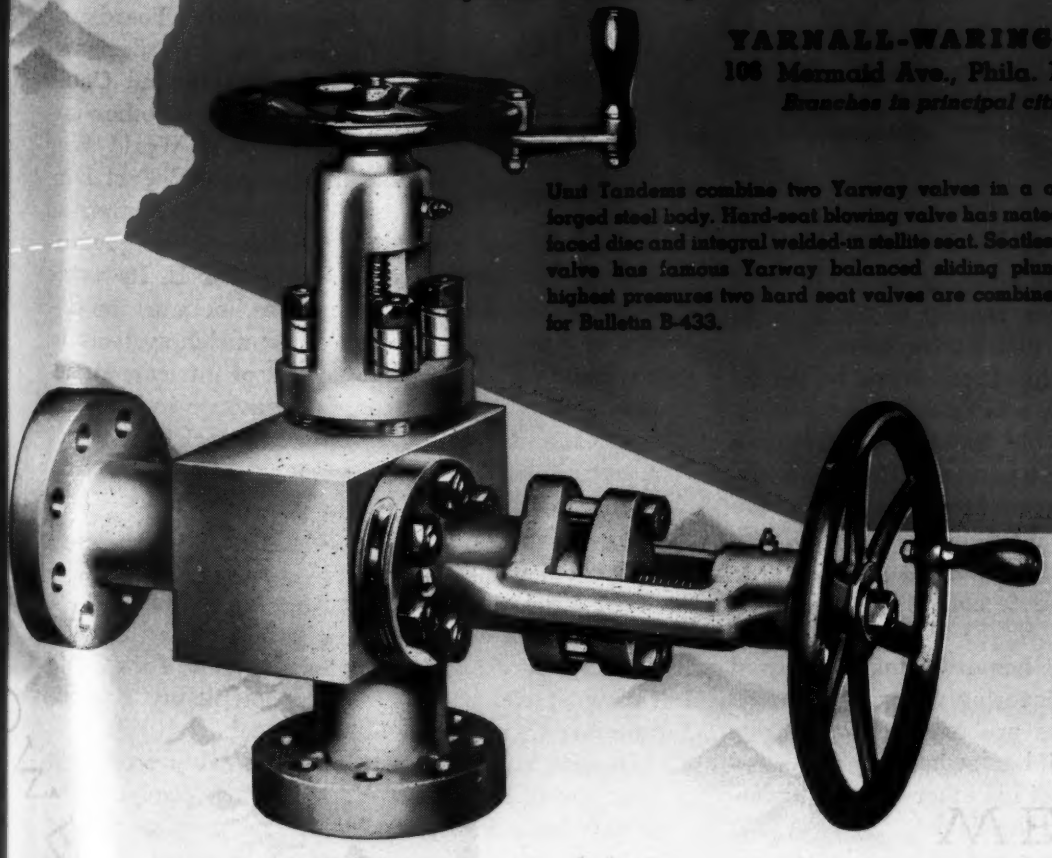
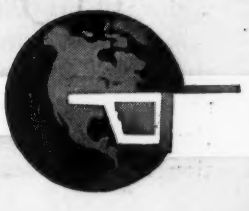


Unit Tandems combine two Yarway valves in a one-piece forged steel body. Hard-seat blowing valve has mated stellite-faced disc and integral welded-in stellite seat. Seatless sealing valve has famous Yarway balanced sliding plunger. For highest pressures two hard seat valves are combined. Write for Bulletin B-433.

YARWAY SERVICE GOES ALL THE WAY....



Caisson Man

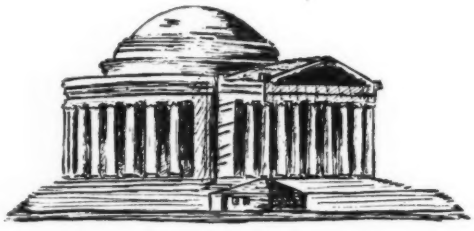
—Starts on Front Cover

in the nation's capital to air bases in the Arctic.

Seelye prefers to speak of himself as a "bottom-of-the-caisson man," and as a stickler for personal follow-through and supervision of the toughest phases of any project on which he works. He is quick to give his partners and associates much of the credit for his firm's success.

Any doubts about Seelye's own role in the firm are quickly dispelled as you chat with this diffident, ruddy man with close-cropped gray hair, who looks to be in his late fifties. You learn that he has just flown back from the Arctic Circle and still has his "air legs" after personally inspecting a string of air bases the firm has helped design for the United States Air Force's "Pine Tree" Far North project.

The firm has recently designed three air bases and is supervising construction on four others in France. It has a number of other big defense projects for the Services and for industry under way.



Although there is not much that Seelye is permitted to say about "Pine Tree" (it was a rough trip — his second to the Far North in full parachute gear and with nights spent sleeping on the floor of his plane) he speaks more readily of tough engineering problems he has met nearer home.

For instance, there is his firm's work in saving a Chicago building which was found to be sinking in sand and gravel. The old building in Chicago's Loop—needed for an addition to the Carson, Pirie, Scott and Company department store — was given new foundations by driving steel H-beams to new depths alongside its inadequately supported concrete caissons, using concrete collars as load-transfer elements.

Seelye is very much at home writing a standard text on design or an engineering paper on complex sewage and water works problems, or on bridge building, or how to build a swimming pool — as much at home as in any of his other diverse undertakings at his office or in the field.

A restless, hard-working expert who knows his structural engineering, he likes to tackle tough problems first-hand and to come up with innovations. He is particularly well known for his foundation work. As head of the firm, he has also cannily surrounded himself with able associates. Seelye has done much personally to build up associations with executives in industry, defense authorities, and top-ranking architects; this in turn, has helped the firm win top-flight clients in railroad and highway building, industrial plant construction, and in the construction of war and defense facilities.

The roster of the New York firm's completed work testifies not only to the broad range of experience possessed by its men in civil, mechanical, structural, industrial, and general engineering, but also to the wisdom of the high standards set by its senior partner. The list includes such projects as the structural work for the Thomas Jefferson Memorial in Washington, D. C.; design of the modern, several-times-expanded electronics plant of International Business Machines Corporation at Poughkeepsie, N. Y.; railroad and highway bridges; and sanitary engineering projects.

Inevitably, the two World Wars and the present international conflict have brought new challenges to all departments and have altered the placid course of the partnership. And intermittently, as at present, defense business has accounted for the greater part of the work on its drawing boards.

Seelye's firm designed Camp Kilmer and Camp Shanks among other assignments in World War II; it expanded Fort Dix, built other cantonments and carried out engineering studies for the government in the Pacific during World War II. Its work today, beside that on the air bases, includes the design of a test basin for Navy propulsion systems in Maryland—a job in which a host of intricate structural and equipment problems came up in building channels and installing devices for precision control of water flow. There is the design and construction of an assembly plant for Grumman Aircraft Engineering Corporation, complete with an airfield at Calverton, Long Island.

The firm combines with this work, however, a good number of peacetime contracts. They are designing a series of bridges for the New York State Thruway, and are engaged in completely air-conditioning the Waldorf-Astoria hotel.

Despite an innate reticence — notably stemming from his upstate New York origins—Seelye likes to look back on a period which he spent as a sales engineer with Truscon Steel prior to establishing his own engineering practice, as one of his most profitable experiences. It taught him some elements of salesmanship, he says, which are necessary to the success of any engineer.

Sound Selling vs. Smart Talk

Today, essentially, all of the chemical companies have established technical service and sales-supporting technical work. One corporation has 25 laboratories devoted to this type of work supported by 29 field laboratories. The total investment by the industry in such facilities, must run well into the tens of millions of dollars, which is one measure of how importantly the industry regards the sales function.

It is now estimated that 70% of the average chemical company's sales staff is technically trained compared with probably less than 25% only 20 years ago and an insignificant percentage 30 years ago. This current mode of selling is epitomized in the slogan of one chemical manufacturer, namely, "Serving Industry through Practical Applied Science."

From an article: "Selling . . . Its Importance in the Chemical Industry," by J. Warren Kinsman, Vice-President, E. I. du Pont de Nemours & Co., Wilmington, Del., in Chemical Engineering Progress.

Nalco appreciates the use of its slogan, "Serving Industry through Practical Applied Science", as an example of the modern approach to chemical sales. 100% of Nalco's field service representatives are technically trained to help industry make full practical use of the chemicals and methods developed by the Nalco Laboratories: Water, Microbiological, Physical Chemistry, Organic Chemistry, Corrosion, Micrography, Metallographic, Experimental Boiler, Combustion, Oil Treatment, Paper, Ion Exchange, Weed Control, Production Control.

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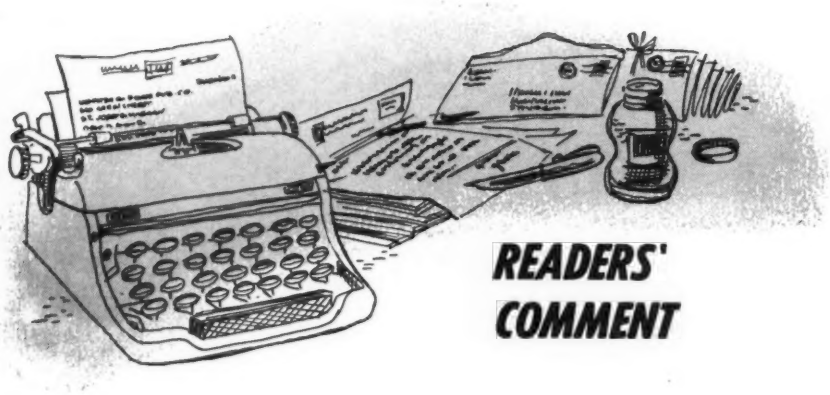


READERS' COMMENT

Ethical Discipline

Sir:

The June issue of your magazine carries some very interesting and timely articles. I have just finished reading Frederick McDonald's "Engineers Need Ethical Discipline" and, speaking from my own 20 years experience in private practice, I know that he is right.

I am one of the Directors of the National Society of Professional Engineers and we have been struggling with the "Professional" questions for a long time in an effort to reach the individual engineer with Mr. McDonald's thought of "self-imposed discipline." In order to spread this idea beyond the regular readers of your magazine, I would like to obtain 25 reprints of this article to send to a few engineers across the country who may be able and willing to help other engineers acquire an attitude of self-discipline.

A. G. Behling
Consulting Engineer
Milwaukee 14, Wisc.

Sir:

Your article "Engineers Need Ethical Discipline" is both timely and valuable to the profession as a thought-provoker.

As secretary to the Sanitary Engineering Division, American Society of Civil Engineers, I would like to obtain twelve tear sheets of the complete article. We are working on a professional program, and this article will be of help to our Executive Committee and Professional advancement group.

John C. Bumstead
Alfred LeFeber & Associates
Cincinnati, Ohio

Sir:

Was much interested to read an article in June issue of CONSULTING ENGINEER by Frederick H. McDonald, Consulting Engineer of Charleston, S. C., whom I have known for many years.

Would it be possible for you to send about six sets of tear sheets of this article? Would like to discuss it with other members of the American Society of Civil Engineers.

James A. Higgs
Director ASCE, District 10
Atlanta 3, Georgia

Sir:

A professional friend handed me a copy of the June issue of CONSULTING ENGINEER to read over the weekend. I must say I was deeply impressed by the scope of your technical coverage in your feature articles, your clear, concise presentation, and the informative departments.

I want to congratulate you and Mr. Frederick H. McDonald for the article "Engineers Need Ethical Discipline." This article is getting down to the "grass roots" of the problems facing the Professional Engineer and his professional standing.

Case histories of several projects with which I have been associated followed the same pattern presented in the article. I believe many Professional Engineers could detail similar experiences where, because of economic reasons his engineering abilities were limited and dictated to by certain individuals in private industry who had no basic engineering training but called the "shots" of what should and would be done. I have found, too, that various government agencies have archaic rules and practices as to engineering requirements, which cannot be surmounted or by-passed except by long discussion and board action. These rules sometimes cost the government double, because in the end what is wanted is usually included later by "operating or maintenance personnel" at a much greater expense than if included in the initial design.

Professional Engineers should not sell their profession "short." The impact of this article is a challenge for each engineer to keep his individual dignity alive. I would like to see this article reproduced in each Professional Engineering State Society Magazine as well as in the *American Engineer*. I am making this suggestion by letter, copy of which is enclosed herewith.

I believe that instead of "Engineers Need Ethical Discipline," a more appropriate title would have been "Engineers Have Ethical Obligations." It is the group we serve, employers or clients, who need ethical discipline.

Kermit B. Hoffman, E. E., P. E.
Vice President
McConathy, Hoffman & Associates, Inc.

● IS THE BRIBER MORE GUILTY THAN THE BRIBED?—ED.

Cooling Tower Research

Sir:

We would like to compliment H. Raymond Baker, Jr., on his aggressive approach to the complex problem of determining the effect of recirculation on large industrial induced draft cooling towers. Mr. Baker was active in the early days of the Cooling Tower Institute and was instrumental in activating our Technical Sub-Committee #2 on Performance, but during the past year he has not had opportunity to follow the progress of the CTI group in its further development of logical and acceptable procedures for accurate determination of the effect of recirculation and a reasonable method of applying such knowledge to the calculation of tower sizes.

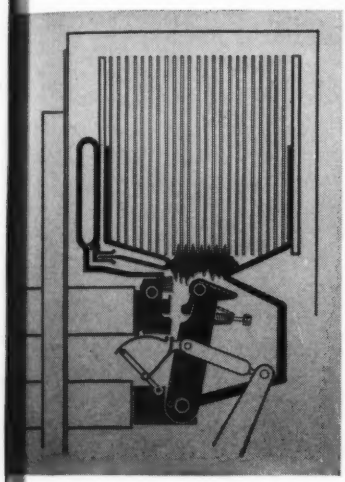
The Cooling Tower Institute employs a full-time field engineer with specially designed instruments for accurate measurement of the psychrometric and aerodynamic variables affecting recirculation. These instruments will be used soon in field studies conducted by the Institute of the Gulf Coast area on towers of all sizes, shapes and designs.

It is the hope of CTI that the results of this study will enable all tower designers, manufacturers, users and consulting engineers to predict with reasonable accuracy the compensation necessary to offset the net effect of recirculation, taking into account plant-site influences and normal fluctuations of wind (direction and velocity) and ambient atmospheric conditions.

As Mr. Baker's concluding paragraph mentioned, the Cooling Tower Institute would greatly appreciate receiving from users of cooling towers any reliable inlet and ambient air wet bulb temperatures and associated data from existing installations which they may wish to make

for over-all economy

Consider these important benefits from I-T-E Metal-Clad Switchgear:



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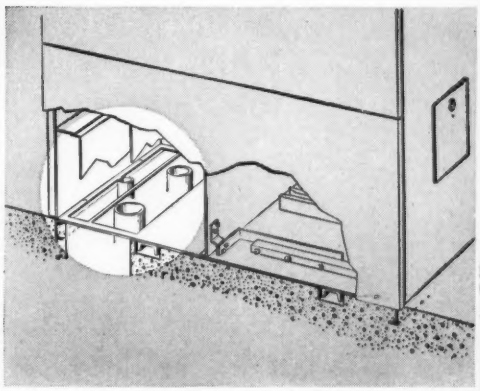

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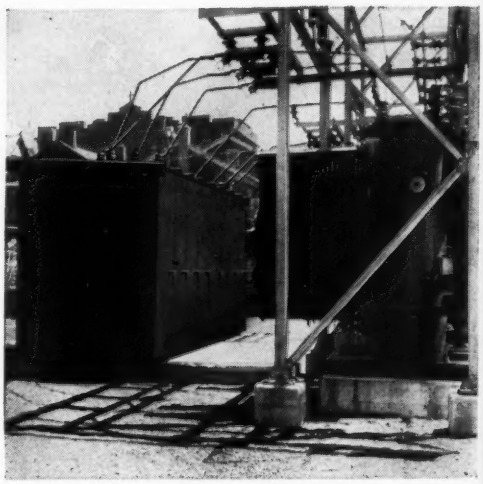
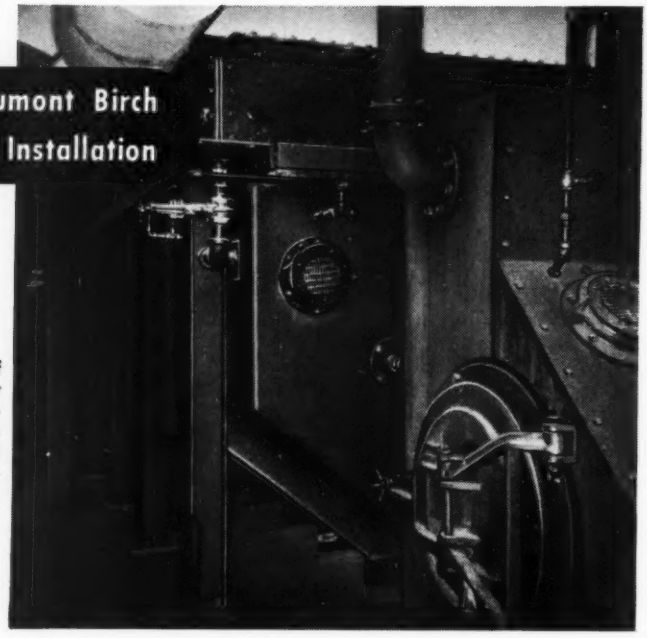


For details call the I-T-E field office nearest you. Look in the classified section of your telephone directory under "Electrical Equipment". Or write for *Catalog Sec. 7000.* I-T-E Circuit Breaker Co., *19th and Hamilton Sts., Philadelphia 30, Pa.*

I-T-E

METAL-CLAD SWITCHGEAR

Another Beaumont Birch Ash Handling Installation



Discharge end section of a flooded hopper for Beaumont hydraulic system showing rugged supporting structure and circular protected observation ports of special heat resistant glass.

Why BEAUMONT BIRCH Hydraulic Ash Handling Systems Assure You

Reliable, Efficient Service

In every detail of Beaumont Hydraulic Ash Handling Systems, you'll find they're designed for practical considerations of boiler efficiency, operating safety, minimum man-hour attention and minimum maintenance.

For example, on flooded hoppers beneath pulverized coal fired boilers, costly shut downs are never necessary when water jet nozzles in the ash hopper require replacing. They are easily and safely replaced *while the boiler is in operation* . . . the rugged sluice gate and operating cylinder are mounted on a single casting, completely shop assembled. This assures perfect alignment of cylinder for long uninterrupted service.

On flooded hoppers, operators are always protected at observation ports by special glass resistant to thermal shock, in addition to a protecting metal guard. Built-in spray washers keep all observation ports clean and free from dirt and fog.

These and many other points, such as, sluiceways, sumps, dewatering bins, flyash handling systems and other supplemental equipment are only a small part of the attention to details that are characteristic of Beaumont Birch Systems.

Power and Consulting Engineers specify Beaumont Birch Hydraulic Ash Handling Equipment because they are assured of design, engineering and construction to exacting specifications!

Beaumont's background of over fifty years in the design and manufacture of ash handling systems gives you long service life with a minimum of maintenance.

For complete details of the many efficiency and economy features of Beaumont Hydraulic Ash Handling Systems, call in a Beaumont Birch engineer or write direct.

Beaumont BIRCH COMPANY

1529 RACE STREET, PHILADELPHIA 2, PA.

DESIGNERS — MANUFACTURERS — BULK MATERIAL HANDLING SYSTEMS

available to us. All such communications will remain confidential and the data codified and tabulated for study by the TSC #2 on Performance. Correspondence should be addressed to Cooling Tower Institute, 444 Emerson St., Palo Alto, Calif.

Raymond C. Kelly
Cooling Tower Institute
Palo Alto, California

Wrong Union

Sir:

No doubt by now our good friends at Union Electric Company have called your attention to the error in the table on page 29 of the July issue. We feel sure from the correctness of the body copy that this was just a slip and that Mr. Bergen is fully informed of our place in atomic energy research, reactor development and production of atomic materials.

While we are always pleased to be recognized for our ten-year record in atomic energy, and although our people at Oak Ridge *did* lend a hand in providing background data on reactor development, nuclear fuels, and similar subjects for all four of the study teams that made the surveys on atomic power, we feel that it would be misleading for anyone to harbor the idea that we were sponsoring one of these studies or were engaged in or investigating these phases of the commercial power business. This letter is just insurance that you will have the correct story on file.

As you may know, Union Carbide operates for the Atomic Energy Commission the gaseous diffusion plants at Oak Ridge, Tennessee and Paducah, Kentucky for the separation of the atomic fuel, Uranium 235 and Oak Ridge National Laboratory, center for the development of atomic reactors, production of radioactive and stable isotopes, and basic atomic energy research.

G. B. Moynahan
Union Carbide and Carbon Corp.

● OUR APOLOGY TO UNION ELECTRIC . . . OUR THANKS TO UNION CARBIDE. —ED.

Publicity

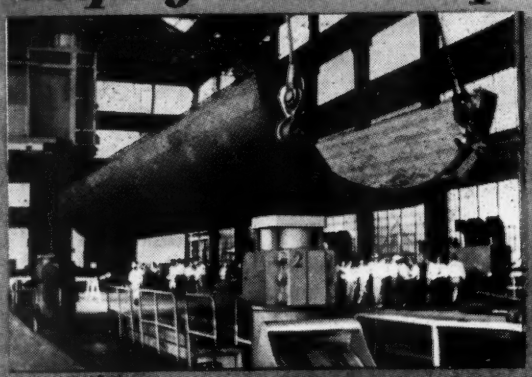
Sir:

That is a powerful article you had in your June issue by V. W. Palen, "Your Firm Can Afford Publicity." May I have permission to reprint it *in toto?*

I was with a brokerage firm as director of research and statistics before starting my own public relations company this May. (Before that I was public relations director for a hospital for 5 years; and before that advertising manager for an in-

Steam is literally the life-blood of our American ecoooomy. Through it, the energy in our store of fuels is made available in useable form. Steam always has been taken for granted because it's cheap. But, with the need for the greater efficiency of higher pressures and temperatures to overcome increased fuel and operating costs, major engineering concentration is required on the problem of . . .

keeping steam cheap



EASILY BENDING STEEL PLATES THIS THICK TO MAKE STEAM BEHAVE AT 2700 POUNDS PRESSURE

"Keep power costs down in the face of almost universal inflation." This is the challenge faced by public utility and steam generation engineers for many years. One important way they have met it is by squeezing more energy from common fuels through the utilization of vastly higher steam pressures and temperatures for maximum efficiency.

With temperatures advanced to 1100 degrees F and pressures up to 2700 pounds, every step in boiler manufacture—from tube fabrication to field erection—calls for precision standards never before known. For example, gigantic shells of steam drums are made by bending (with fingertip push-button control) massive 42-foot sections of 6-inch thick steel plate, on the largest press of its kind in the world. This rapid, precision bending is the beginning of a long series of manufacturing steps, ending with rigorous examination of welds under B&W's 2,000,000-volt X-ray to insure integrity of seams that must hold at these great pressures.

N-154

Few stories of achievement in American industry can parallel the endless and painstaking efforts of American power engineers to derive the maximum benefits from the nation's fuel resources. B&W's Research and Engineering Program, always apace of power progress, is geared to this relentless drive toward more energy at lower cost.

BABCOCK & WILCOX

BOILER DIVISION

This NEW METHOD DRIES AIR

PRECISELY as you want it

- to control your product's quality
- to prevent condensation on your product or material
- to prevent changes due to moist air in contact with your product
- to protect your material from dampness
- to protect your processing of moisture-sensitive material
- to DRY your material or product
- to pack or store your product safe from moisture damage
- to get exact moisture control for the precise atmosphere condition you need
- to provide precise atmospheric conditions for testing
- to increase your air conditioning capacity
- to DRY large quantities of fresh air from outdoors

The Niagara's Controlled Humidity Method using HYGROL moisture-absorbent liquid is

Best and most effective because . . . it removes moisture as a separate function from cooling or heating and so gives a precise result constantly and always. Niagara machines using liquid contact means of drying air have given over 20 years of service.

Most reliable because . . . the absorbent is continuously reconcentrated automatically. No moisture-sensitive instruments are required to control your conditions.

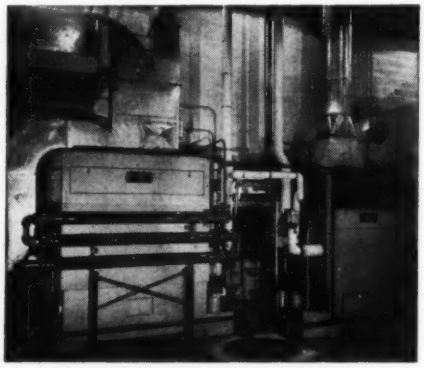
Most flexible because . . . you can obtain any condition at will and hold it as long as you wish in either continuous production, testing or storage.

Easiest to take care of because . . . the apparatus is simple, parts are accessible, controls are trustworthy.

Most compact, taking less space for installation.

Inexpensive to operate because . . . no re-heat is needed to obtain the relative humidity you wish in normal temperature ranges and frequently no refrigeration is used to remove moisture.

The cleanest because . . . no solids, salts or solutions of solids are used and there are no corrosive or reactive substances.



Niagara Controlled Humidity Air Conditioning

This method removes moisture from air by contact with a liquid in a small spray chamber. The liquid spray contact temperature and the absorbent concentration, factors that are easily and positively controlled, determine exactly the amount of moisture remaining in the leaving air. Heating or cooling is done as a separate function.

For complete information write

NIAGARA BLOWER COMPANY

Dept. CO 405 Lexington Ave., New York 17, N. Y.

District Engineers in Principal Cities of United States and Canada

dustrial manufacturer, Dresser Manufacturing Division of Dresser Industries).

As I saw how young companies started, how important public relations was to them, and how little they knew about it, I got enterprising and decided to try to do something about it myself. Your article should certainly give my prospective customers some very important pointers.

Katheryn H. Power
Pittsburgh 19, Pennsylvania

"Live" Magazine

Sir:

I have now had a chance to see the article appearing under my name in your June issue and want to thank you for the excellent presentation you gave it.

Incidentally, you'll be interested to know that your magazine is apparently a very "live" one—I have received numerous letters commenting on the article, as well as quite a number of telephone calls.

Carl Heyel, Associate Partner
George H. Elliott & Company
New York 17, New York

Leading Voice

Sir:

Your articles are good, varied enough to cover all phases of engineering, and you should become the leading voice of the consulting engineering profession. Try to add legal decisions and pending cases covering engineers, architects and contractors.

John R. Quinzio
Consulting Engineer
North Tonawanda, New York

Sir:

It is the intention of this letter to offer my sincere appreciation of your magazine CONSULTING ENGINEER.

Naturally, I read this magazine from cover to cover, and I heartily congratulate you on the excellence of the articles contained therein, the fact that you are educating the public regarding services offered by consulting engineers, and your efforts to weld consulting engineers into a group.

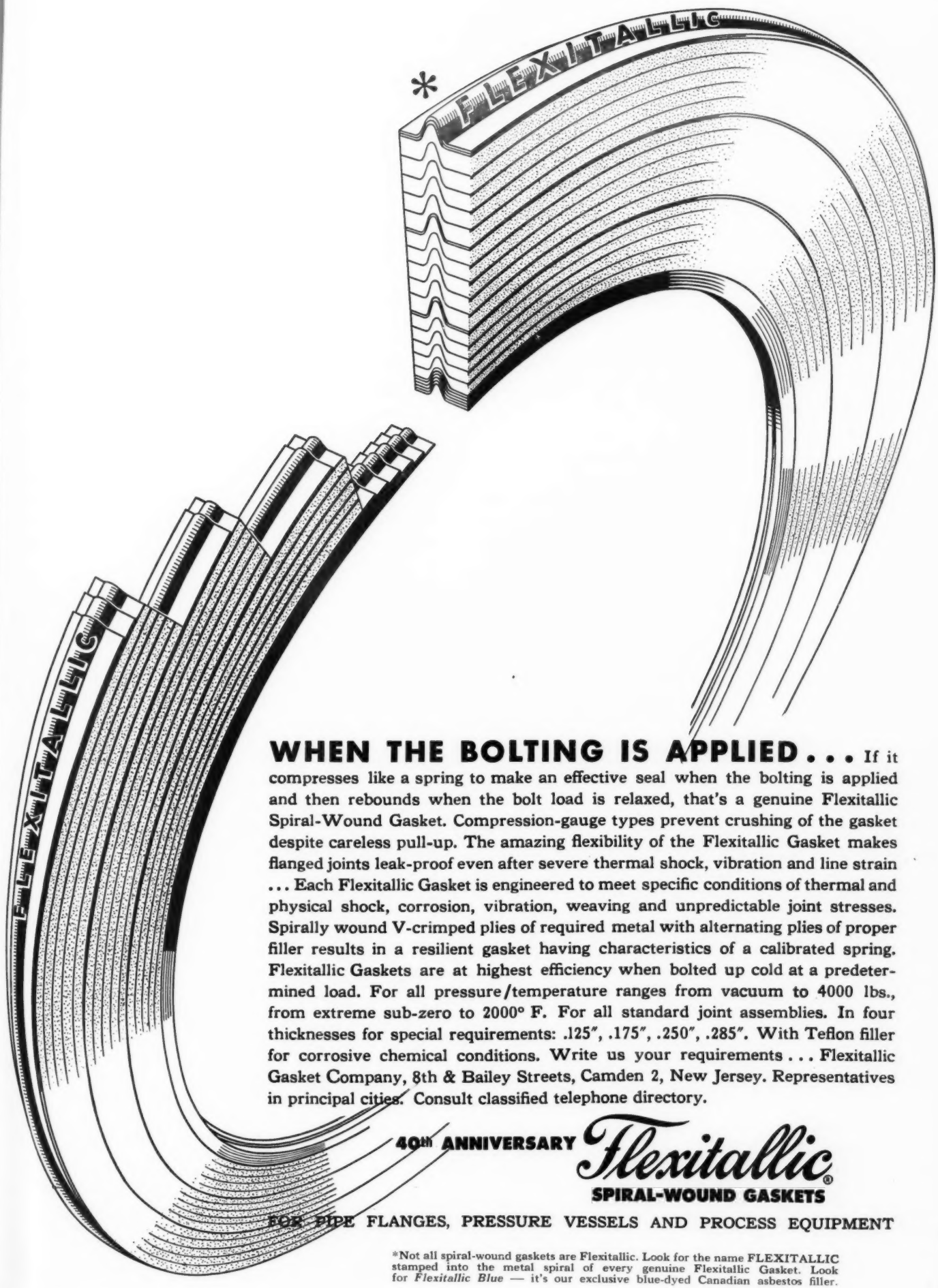
David C. Pfeiffer
Consulting Engineer
Dallas, Texas

Reader Service

Sir:

Please send me tear sheets of the article by Mr. Gusrae concerning "elevator history."

John R. Hersey
The C. O. Bartlett & Snow Co.
Cleveland, Ohio



WHEN THE BOLTING IS APPLIED . . . If it compresses like a spring to make an effective seal when the bolting is applied and then rebounds when the bolt load is relaxed, that's a genuine Flexitallic Spiral-Wound Gasket. Compression-gauge types prevent crushing of the gasket despite careless pull-up. The amazing flexibility of the Flexitallic Gasket makes flanged joints leak-proof even after severe thermal shock, vibration and line strain . . . Each Flexitallic Gasket is engineered to meet specific conditions of thermal and physical shock, corrosion, vibration, weaving and unpredictable joint stresses. Spirally wound V-crimped plies of required metal with alternating plies of proper filler results in a resilient gasket having characteristics of a calibrated spring. Flexitallic Gaskets are at highest efficiency when bolted up cold at a predetermined load. For all pressure/temperature ranges from vacuum to 4000 lbs., from extreme sub-zero to 2000° F. For all standard joint assemblies. In four thicknesses for special requirements: .125″, .175″, .250″, .285″. With Teflon filler for corrosive chemical conditions. Write us your requirements . . . Flexitallic Gasket Company, 8th & Bailey Streets, Camden 2, New Jersey. Representatives in principal cities. Consult classified telephone directory.

40th ANNIVERSARY *Flexitallic*®
SPIRAL-WOUND GASKETS

FOR PIPE FLANGES, PRESSURE VESSELS AND PROCESS EQUIPMENT

*Not all spiral-wound gaskets are Flexitallic. Look for the name FLEXITALLIC stamped into the metal spiral of every genuine Flexitallic Gasket. Look for *Flexitallic Blue* — it's our exclusive blue-dyed Canadian asbestos filler.

SCRAPS & SHAVINGS

INTERNATIONALISTS through and through, we are always happy to see the results of American technical ingenuity spread far and wide throughout the backward areas of the world. We were naturally pleased to find on our desk a press release from Sam Tour & Co., Inc., reporting that Sam Tour, himself, is off to Iceland to study corrosion of water pipes in Icelandic homes. Sam's tour is being financed by the Productivity and Technical Assistance Division of the Mutual Security Administration. We have never met Mr. Tour personally, and we have a nodding acquaintance with only one Icelander (a boy who played a clarinet in a small ship orchestra) so we may be prejudiced in thinking that this project does not entirely measure up to our idea of the way tax money should be spent to disseminate essential technical information in the backward areas. But it is too late now. Sam Tour is in Reykjavik, supposedly collecting specimens from various Icelandic water pipes for further study in his New York laboratory. We can only hope he can find the cause of this corrosion so that future Icelanders will not have rusty rings around their tubs. If further research is necessary, we have a water heater which has been giving us red water for some time, and we will be glad to send Sam a sample without charge.

ARTHUR D. LITTLE's "Industrial Bulletin" published a short treatise on odors in its June issue. Not too much is known about odors even though men have been sticking their noses into the subject since a Roman, T. L. Carus, decided in 47 B. C. that the difference in odors was the result of odor molecules being of different shape. That may not seem like much of a theory, but it is about as good as anyone else has done. At a recent meeting in New York, the ASHVE and the N.Y. Academy of Science decided that nearly everyone who does not have a head cold can distinguish 10,000 or more odors, even at low intensity. Also, they discovered that memory of odors can be permanent. Recognition and recall can take place after many years. We don't know what type of research was involved in this investigation, but they could hardly have done better than to have read Marcel Proust's *Remembrance of Things Past.* We remember that it took about 2000 pages of real mental struggle for him to recollect the odor of coriander cookies.

NEW TYPE WATER FILTER . . . for industrial plant water, municipal water supply and swimming pools

The SPARKLER Model SCJ *Diatomite* self cleaning filter

—combines the uniform consistant quality of diatomite filtering with a quick cleaning system of jet spray wash off of plates and backwash.

The filtering element is composed of orlon cloth covered screen discs that readily take an even pre-coat of diatomite circulated from a slurry tank.

The filter cake can be quickly and completely washed off with a built-in jet spray and the filter cleaned by backwash with a minimum of backwash water and plates recoated ready to resume service within a total cleaning time of 10 to 15 minutes.

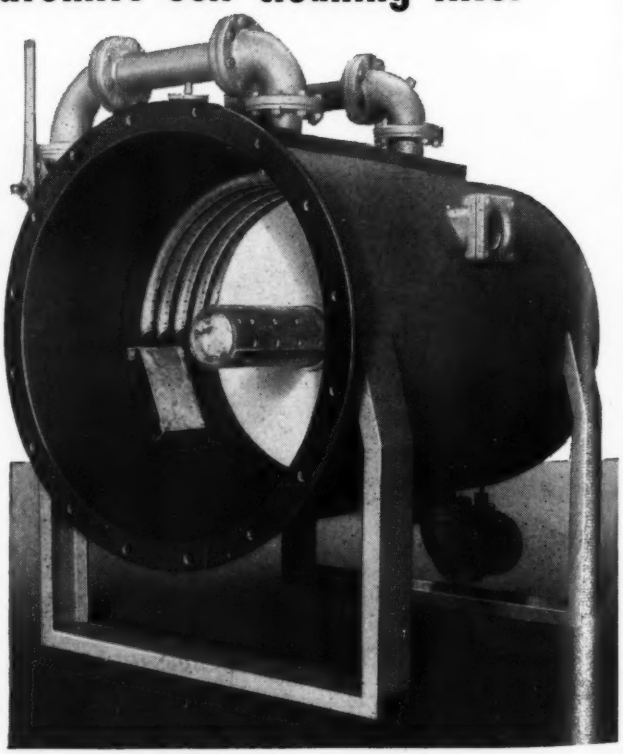
For the first time, in this new development, Sparkler Engineers have successfully combined the desirable features of diatomite filtering and fast self cleaning, without bridging or loss of filtering surface and with the use of very little filtered water at a low flow rate. The distinctive advantages of this type of filter are:

1. Removal of 80% to 100% of bacteria depending on the type of bacteria and the grade of diatomite used in addition to all suspended matter either colloidal or solid. Thus the required chlorination is reduced materially.
2. First cost of a SCJ filter installation is about half that of a sand filter of equal flow capacity.
3. Floor space required for a Sparkler Model SCJ filter is much less than usually anticipated when compared with some other types of filters. The large size SCJ filter with a capacity of 96,000 G.P.H. requires a floor space of only 97" x 77" with overall height of 84".
4. Operation is simple and can easily be handled by any plant mechanic.

Standard single SCJ filter units available in capacities up to 96,000 G.P.H. Multiple units can be used for larger requirements. Also, larger single units can be custom built when desired.

Personal supervision of each installation is made by a Sparkler engineer.

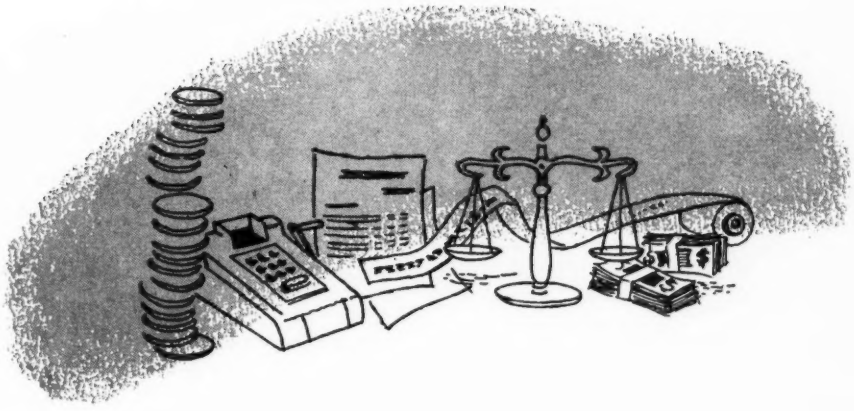
WRITE MR. DAN D. BALDWIN FOR PLANS AND PRICES ON YOUR REQUIREMENTS



SPARKLER MANUFACTURING CO., Mundelein, Ill.

MAKERS OF FINE FILTERING EQUIPMENT FOR INDUSTRIAL USE FOR OVER A QUARTER OF A CENTURY.

ECONOMIC NEWS NOTES



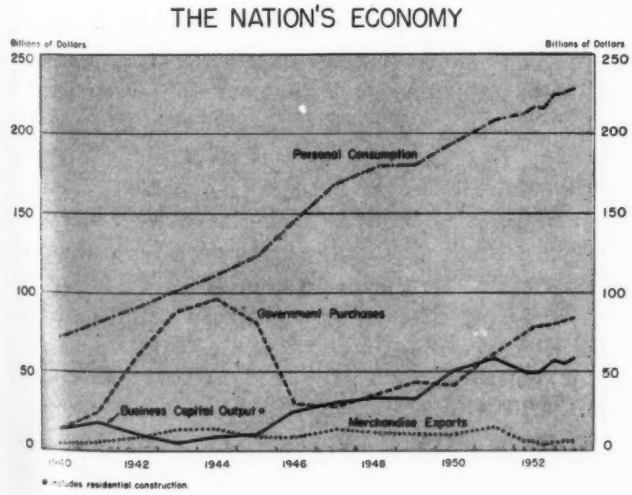
E. F. Mac Donald
INDUSTRIAL ECONOMIST

COLOSSAL FINANCING In the largest transaction of its kind ever negotiated in private financial channels, the Ohio Valley Electric Corp. will borrow $420 million from a group of 52 insurance companies, banks and penison funds. The multi-million dollar loan will provide facilities for supplying power to the Atomic Energy Commission's gaseous diffusion plant under construction near Portsmouth, Ohio. The Ohio Valley company, owned by 15 private utilities, has contracted to supply the AEC plant with 1.8 million kilowatts, the largest demand for power ever made by a single customer.

ATOMIC BITS The Joint Atomic Energy Committee, conducting its first public hearings on private development of atomic power, was told that an economically feasible nuclear power plant could be put into operation in about 10 years. The statement was made by Mr. W. Cisler, representing the Dow Chemical—Detroit Edison group . . . . The first atomic power reactor for civilian use will have to be built with Government funds, according to officials of Westinghouse Electric. They told the committee that their company's experience in reactor construction indicated that it could appropriate "but a trickle" of the total needed to build a full-scale commercial power reactor . . . . Dr. E. Walker, Dean of Penn State, suggested that if private atomic energy industry is to be developed, Congress had better start making it possible for schools to train atomic engineers.

ECONOMIC INDICATORS The accompanying chart shows the expansion of major categories of demand for goods and services from 1940 through the first half of this year—over threefold in personal consumption, fourfold in business investment outlays, and some sixfold in spending by federal, state, and local governments. Reduced spending by any one of these major sources has to be made up by increased outlays in one or more of the other categories in order to avoid a downturn in business activity. So far in the postwar period, downturns have been confined to specific industries, occurring at different times—"rolling adjustments"—with an uninterrupted rise, except for the 1948-49 recession, in the over-all level of business activity. Trouble arises when reductions in spending coincide and touch off a general retrenchment.

THE NATION'S ECONOMY



ENGINEERING ECONOMICS Machinery & Allied Products Institute will finance a National Center of Education and Research in Dynamic Equipment Policy at Illinois Institute of Technology. The Center will offer courses in capital equipment and replacement on undergraduate and graduate levels as well as specialized seminars for those already out on the firing line. Research in applied equipment policy and dissemination of results to industry will be major functions of the Center.

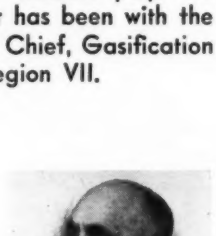
POWER BEHIND BOOM The success story of the year is electric power. By the end of the first quarter, the cumulative total of electric power distributed was 9% ahead of the corresponding period last year. Steady gains widened the gap to over 12% by the end of August. From a generating capacity of 63 million kw in June, 1950, electric power plants have expanded to a current potential of 84 million kw. Turbo-generators being installed will boost capacity to over 93 million kw by year-end.

IN PASSING New construction outlays in first half hit highest level in history, but F. W. Dodge reports contract awards down in June and July and way under year-ago figures . . . ***Planes,*** publication of Aircraft Industries Assoc., reports that corporation-owned aircraft flew almost as many plane-miles last year as the total logged by all scheduled domestic airlines . . . . ***Carrier Corp.*** reports six out of every 100 homes built this year will be equipped with all-year air conditioning, ... ***U. S. Steel*** sees a downturn ahead in demand. With one of the main props to recent high-level rate of steel demand, the balancing out of inventories by consumers, removed, Chairman Fairless expects a drop in demand and output in the 4th quarter . . . . ***General Electric*** plans to increase its staff of fundamental research workers by about 50%. 180 scientists will be added to the 270 now engaged in such research . . . . ***International Harvester*** has announced the most drastic cutback in tractor production in the postwar period.

PHOTO SHOWS A PORTION OF THE INSTALLATION THAT WAS USED FOR THE UNDERGROUND GASIFICATION EXPERIMENTS

Underground Gasification of Coal ... the Gorgas Experiments

James L. Elder graduated from Pennsylvania State College in 1931 with a BS degree in Chemical Engineering. He then spent four years with the West Virginia Pulp and Paper Co., serving as chemist and assistant pulp mill superintendent. Since 1935, Mr. Elder has been with the U. S. Bureau of Mines and he is now Chief, Gasification Branch, Fuels Technology Division, Region VII.



Milton H. Fies is at present vice president in charge of coal operations, Alabama Power Co.; consulting mining engineer for the U.S. Bureau of Mines; consulting engineer for the Southern Co.; and treasurer and trustee of Southern Research Institute. Recipient of a Doctor of Science degree from the University of Alabama, he is an authority on the various aspects of coal technology.

JAMES L. ELDER and MILTON H. FIES

SINCE 1946 the Bureau of Mines, U. S. Department of Interior, and the Alabama Power Co. at Gorgas, Alabama, have conducted field-scale experiments on underground gasification of coal. The intent of these efforts has been the development of a low cost process whereby either the chemical constituents or the energy of the coal can be brought to the surface in useable form. Then these products may be utilized for synthesis of liquid fuels and other organic chemicals, or the energy may be applied as heat or used to produce power. Among other possible benefits from such a process are the utilization of coal seams that are uneconomical for mining because of high ash content or poor mining conditions and of coal which remains in mined-out areas.

Experiments with "Stream" Type Operation

Between 1946 and 1951, field trials featuring "stream" type operation were conducted on relative-

ly flat coal beds. A passage in the coal bed was prepared by mining methods, and a stream of air or other gas-making fluid was passed along an incandescent coal face. It was found that the roof above the coal bed fused and swelled under the action of heat, filling the entries and the space from which the coal had been consumed. This roof action tended to force the reactants to flow along the reaction face or through the fissures in the coke that formed adjacent to the face. A portion of the air bypassed the reaction zone through fissures in or above the burned-out area, bringing about combustion or dilution of the gas near the outlet of the system. The proportion of bypass air increased with the age and width of the burned-out area, and consequently reduced the quality of the gas. This fostered attempts to develop a method for forcing the air or other gas-making fluids into more intimate contact with the carbonaceous materials. Detailed reports[1] fully covering this work have been published.

An independent program of laboratory and field-scale experimentation directed toward establishing a passage through a coal bed by electrical methods[2] was conducted at the Missouri School of Mines and at Hume, Missouri, under a cooperative agreement between the Missouri School of Mines and the Sinclair Coal Co. of St. Louis, Missouri. The results of this investigation were considered promising, and it was decided to apply the electrical method at Gorgas in preparing a system for underground gasification of coal. A cooperative agreement was made between the Federal Bureau of Mines and the Sinclair Coal Co., and during 1951 and 1952 a series of field-scale experiments were performed at Gorgas.

Electrolinking-Carbonization

The electrical method (electrolinking-carbonization) affords a means of establishing a gasification system underground without the necessity of mining passages by conventional methods. It does not represent the only method that may be used, and in the future, the simple installations at Gorgas may be modified and combined with other methods to increase effectiveness.

Coal, as it occurs in its natural bed, is virtually a nonconductor of electricity. If electrodes are placed at two points in the coal bed and a potential is applied, some current will pass through the coal and some will dissipate into the surroundings. The current that passes through the coal causes changes in the structure of the carbon, and these changes progressively increase the conductivity of the carbonaceous material. After a time coke is formed, and a good electrical path is established. Continued use of electric current results in the carbonization of appreciable amounts of coal and the evolution of quantities of gas, tar, and other carbonization products. The coke formation produced during the operation provides a bed of hot, cracked, and porous carbonaceous material through which air or other gas-making fluid may be passed.

When applying the method at Gorgas, two boreholes were drilled from the surface to the coal bed, electrodes were placed in the coal, and electric current was passed between them. Various electrode spacings were tried, but during 1952 a spacing of 150 to 155 ft was used to successfully establish three gasification systems by means of electrolinking-carbonization. This spacing does not represent either the maximum attainable or the optimum. It represents a practical maximum attainable with the equipment which was then available.

Trial Procedure

Originally, it was planned to use electrolinking-carbonization as a method of site preparation followed by operation with either unidirectional air flow or periodic air flow reversals until deterioration in product quality occurred. Then a new electrolinked system was to be added at an extremity of the original area and operation continued, with the gas-making fluid entering at one end of the original system, flowing through it, and thence through the entire length of the new addition. Thus, the new system would enforce intimate contact among the reactants and would act as a reduction zone. Application of the plan would lead to the development of

PRODUCER GAS FROM UNDERGROUND GASIFICATION BURNS AT ONE OF THE 12-INCH OUTLET BURNERS

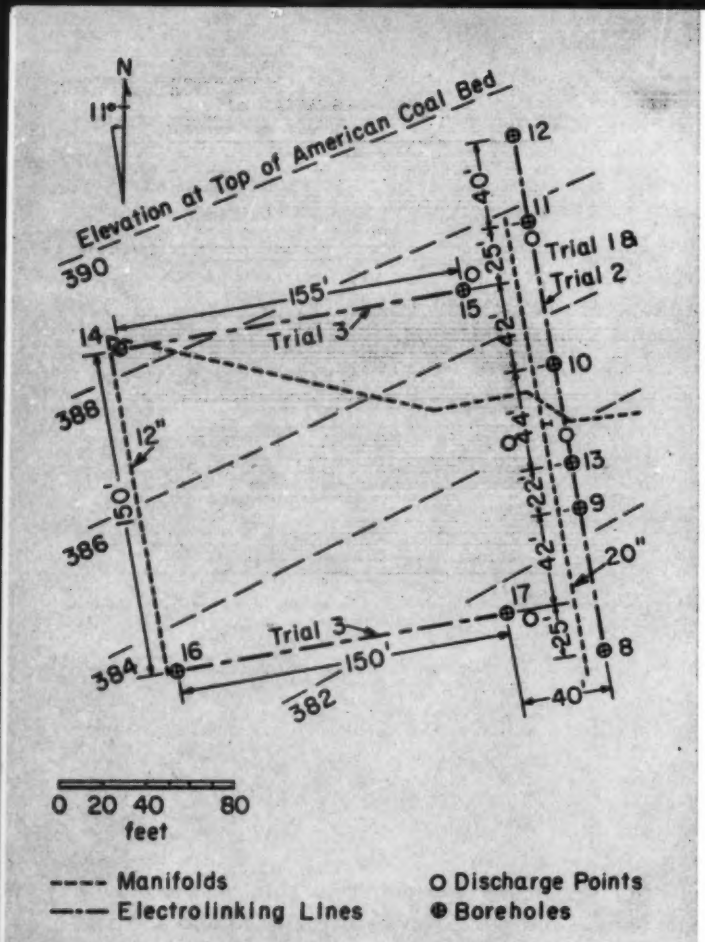


FIG. 1—PLAN OF SITE USED FOR GASIFICATION TRIALS

a fixed inlet, periodically changed outlet, type of unit. This plan appeared to offer a solution to the problem of maintaining contact between reactants which, as indicated by preceding experimentation, is of major importance.

Site Characteristics

At the Gorgas site, the America coal bed was chosen for the gasification tests. This coal bed is nearly flat, has an effective thickness of approximately 3 ft, lies 180 ft below the surface, and contains several fireclay partings. In the portion of the bed used in the experiments, the coal is of high-volatile-A bituminous rank with the following analysis:

Ultimate analysis, percent	
Hydrogen	4.4
Carbon	65.3
Nitrogen	1.4
Oxygen	7.0
Sulfur	1.7
Ash	20.2
Heating value, Btu per lb	11,610

Fig. 1 is a plan of the site used for the gasification trials. The first successful electrolinking-carbonization development was completed in January 1952, using Boreholes 12 and 13 spaced 152 ft apart and drilled 10-in. diameter to the coal bed. These boreholes were used to place the 4-in. diameter electrodes, and during later operation, as air-gas inlets or outlets.

Previous rather unsatisfactory attempts at electrolinking-carbonization had opened a 67-ft passage between Boreholes 8 and 9 at the southern end of the new system, and enough coal had been gasified along this passage to bring about deterioration of gas quality. Following electrolinking-carbonization, repeated attempts were made to operate the combined units as originally planned, with the air inlet at Borehole 8 and product gas discharge at Borehole 12. However, with the fluid flow in the opposite direction the products were superior in quality, and this operation of the system was more practicable. Consequently, air was admitted at the northern extremity of the new system through Borehole 12 or 11, and the product gases were removed at Borehole 8. Gasification was continued from January to May.

Generally, the system was operated at an air input rate ranging from 1150 to 1770 cfm. For a period of 1400 hours, 60 million cu ft of gas were produced having an average heating value of 83 Btu per cu ft. During a second period of 670 hours, near the end of the operating life of the system, 35 million cu ft of gas were produced having an average heating value

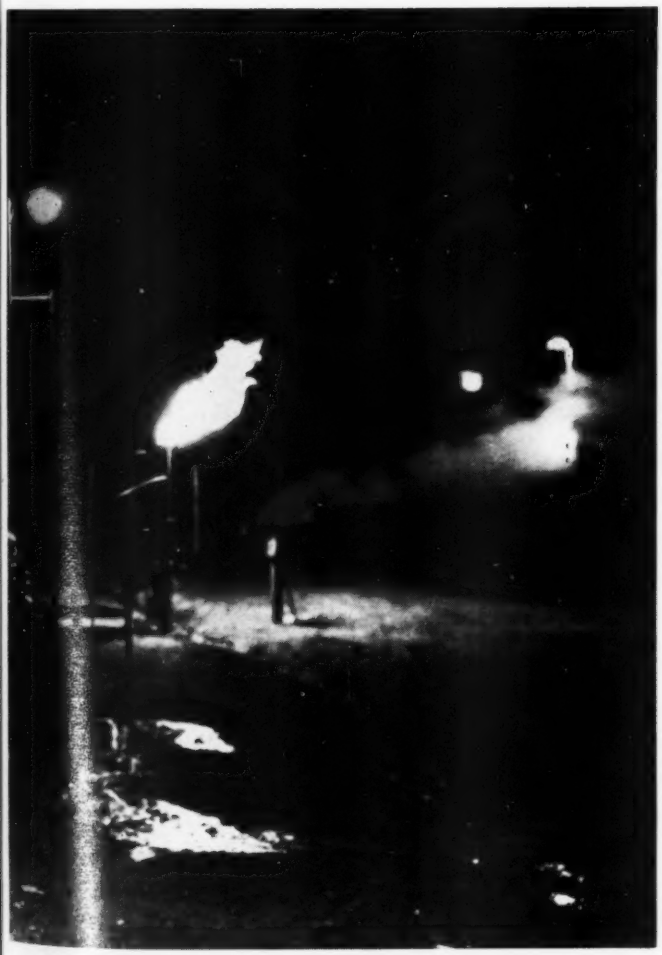
NIGHT VIEW SHOWS THE CARBONIZATION GASES FROM AN

of 58 Btu per cu ft. For a portion of the most efficient operating period, gas composition was as follows:

Analysis, percent	
Carbon dioxide	8.9
Illuminants	0.3
Oxygen	0.3
Hydrogen	11.6
Carbon monoxide	13.4
Methane	2.5
Nitrogen	63.0
Heating value, Btu per cu ft	112

Under most conditions, system operation was smooth and steady, with gas quality changing very slowly over extended periods although trial results were complicated somewhat by the attempts to utilize a flow in the reverse direction. Thus, the results presented are confined to those which were obtained with the air inlet at one end of a newly electrolinked system, and the gas discharge at the extremity of the adjacent deteriorated area.

Observations during operation of the gasification phase indicated that the rate of coal consumption was highest near the inlet. This is the point of maximum oxygen availability. As gasification continued, the perimeter of the area of complete coal gasification moved away from the inlet borehole in nearly all directions, with the downstream section growing at the greatest rate. Apparently when the area of complete coal gasification reached or approached closely the downstream end of the system, the quality of the gas deteriorated. Finally unreacted oxygen appeared.



ELECTROLINKING TRIAL BURNING AT A DISCHARGE POINT

Following development and operation of this unit, two systems using borehole spacings of 150 and 155 ft were installed on east-west lines. These systems, the first between Boreholes 14 and 15 and the second between Boreholes 16 and 17, were located so that their respective discharges would enter the northern portion and the southern end of the deteriorated system. Thus, the three units comprised three sides of a square, with the two western boreholes farthest from the degenerated system.

In view of previous results, it was decided to operate both new systems with unidirectional flow, and to utilize the deteriorated system as a collection main and common discharge point for the gaseous products. After successfully completing electrolinking-carbonization of the two systems, the northern unit was placed in operation in the latter part of August and the southern unit early in September.

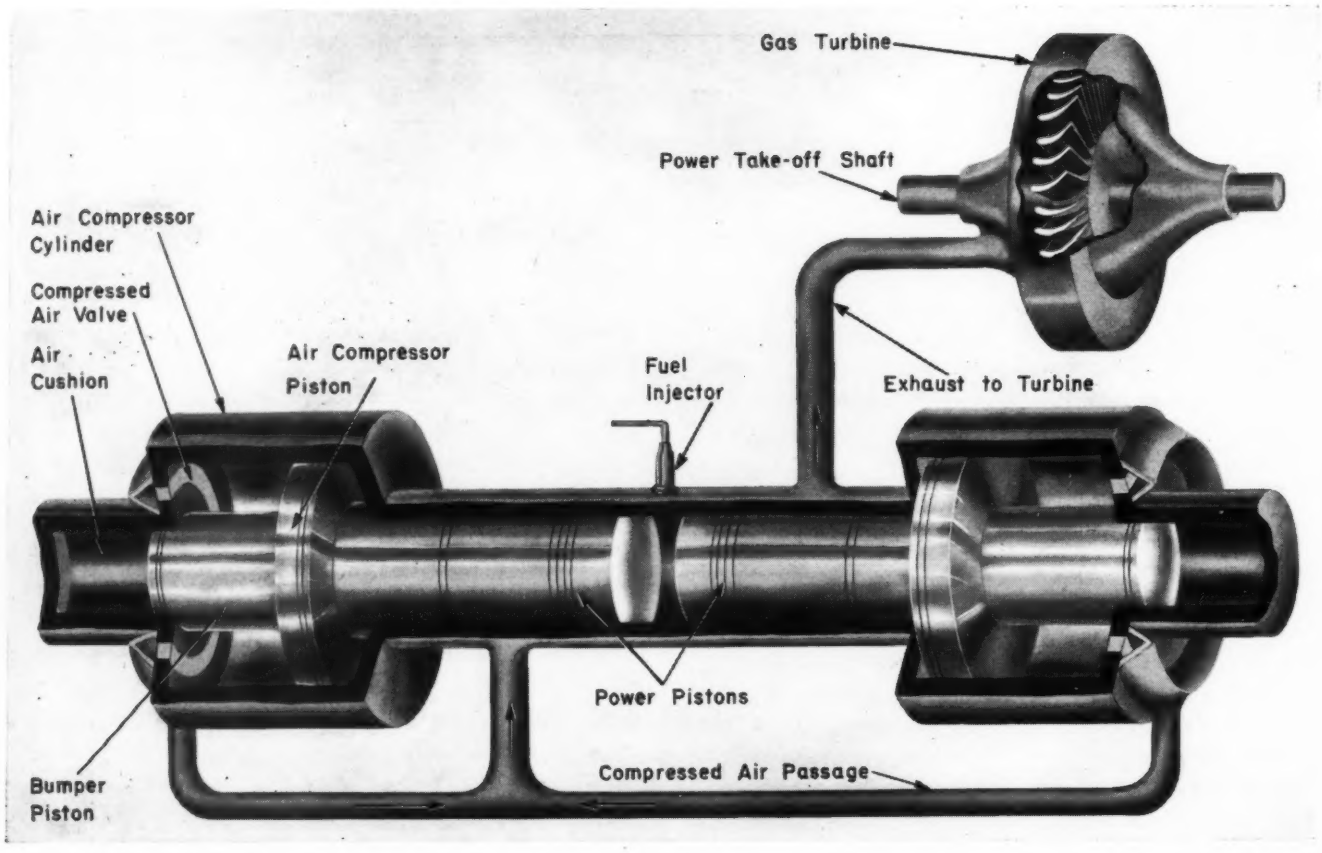
The northern system was brought into operation using air as the gas-making fluid, and a relatively high rate of production was attained at an early date. The southern system was retarded by operating at a reduced input air rate so that it could be used later for experimentation with gas-making fluids other than air. The input rate to the two systems was individually measured and adjusted, but the outputs were mixed and measured at a common discharge point, Borehole 8.

Unidirectional operation of the combined systems was continued for a period of 1557 hours. Approximately 75 percent of the air was introduced in the northern section and 25 percent in the southern section. Flow was reversed several times for a total of 22 hours when it was believed necessary to clean the system and adjust its operation. During the entire period from August 28 to November 3, the air input averaged 1595 cfm and the gas output 1612 cfm. The 151 million cu ft of gas produced had the following average composition:

Analysis, percent	
Carbon dioxide	10.5
Illuminants	0.3
Oxygen	0.9
Hydrogen	8.4
Carbon monoxide	10.7
Methane	1.8
Nitrogen	67.4
Heating value, Btu per cu ft	86

For 504 consecutive hours of peak operation, the

(Continued on page 62)



THE FREE-PISTON ENGINE OPERATES ON THE DIESEL CYCLE, EXPLOSIONS TAKING PLACE BETWEEN THE POWER PISTONS. AS PISTONS MOVE APART, AIR IS COMPRESSED IN COMPRESSOR CYLINDERS. AIR SCAVENGES POWER CYLINDER AND PASSES THROUGH GAS TURBINE WITH EXHAUST. FORCE FOR RETURN STROKE IS FROM AIR CUSHIONS.

Free Piston Engines

STAFF REPORT

American designers are finally showing signs of interest in free piston engines. This engine, combined with a gas turbine, offers simplicity of design and high efficiency.

ON JULY 14, 1868, I. B. T. Babbitt of New York City received U. S. Patent 79,938 for an invention purported to be a "method of generating power by compressing air within a suitable enclosure through the action of a free and unrestrained and independent piston." It sounds impractical. Nevertheless, it was the first officially recorded American idea for free piston engines.

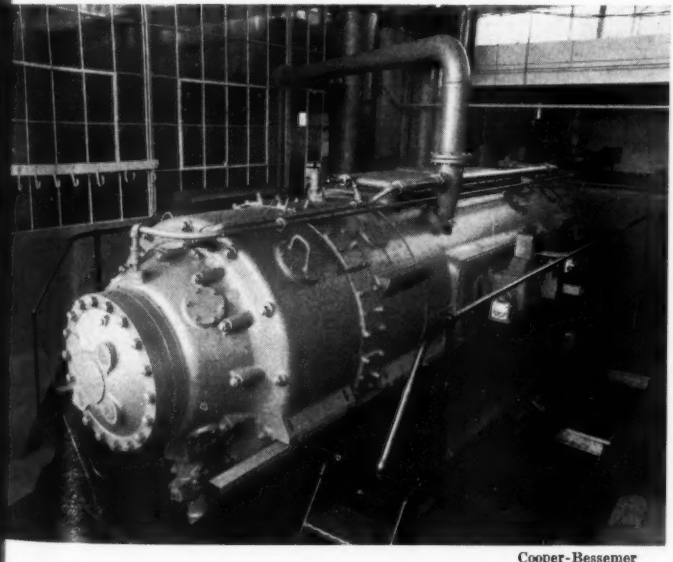
This dispels the notion created by a flurry of articles in the news and trade press that the free piston engine principle is a recent development. And it demonstrates again how important technological progress is to the successful application of an idea. Shortly after World War I, utilizing the results of a more modern technology, R. Pateras Pescara a Frenchman by adoption, designed what was probably the first commercially practical free piston engine. Unfortunately, it seems that Pescara is a very cautious and reticent man and in his reports he uses extraneous material in reporting his engines' actual characteristics and performance. Looking back through his early reports and papers, most must be discarded as worthless because of these precautions and misleading data.

One of the ideas originally motivating Pescara was the use of compressed air from the free piston

engine to drive the rotor of a helicopter by ejecting the air from nozzles at the tips of the blades. In those days, the idea did not go far because of the many basic problems unsolved in helicopter design as well as in the design of the free piston engine. It is interesting to note that serious consideration is again being given to the use of the free piston engine for jet propelled helicopters. In fact, considerable research was done in this field at Georgia School of Technology.

European research continued but, until recently, very little was known about the free piston engine in this country, and only little more was known outside a small circle of Europeans (French, Germans and Swiss), and this despite the fact that Pescara obtained a U. S. patent on his engine in 1937.

The U. S. Navy captured enemy submarines in World War II and found them using Junkers air compressors that were of the free piston design. Experimenting with these engines, the Navy found that they had a number of advantages including high thermal efficiency, very little vibration, and that they were easy to maintain and occupied little space for the horsepower developed. It is not known



Cooper-Bessemer

THE COOPER-BESSEMER 1500 HP FREE PISTON-GAS TURBINE ON TEST STAND IN THE LAB.

whether the Navy actually built any free piston compressors during the war, but the Navy Experiment Station at Annapolis did engage in research programs on design and application of this compressor. The Navy now seems ready to proceed with a further development, the actual application of free piston-gas turbine prime movers on seagoing vessels.

The Baldwin-Lima-Hamilton Corporation in Hamilton, Ohio worked very closely with the U. S. Navy from the very beginning of this project. Unfortunately, the Navy has classified much design data, application, and operating information, so that it

is difficult to accurately credit Baldwin-Lima-Hamilton with the work they have done.

The Cooper-Bessemer Corporation, again with Navy help, has done design work and has built an engine from a largely commercial point of view. They have made studies to indicate that their engine is applicable in such fields as power generation, pipeline pumping, and marine propulsion. They also speak of future applications in the railroad and automotive and possibly even in the aircraft field.

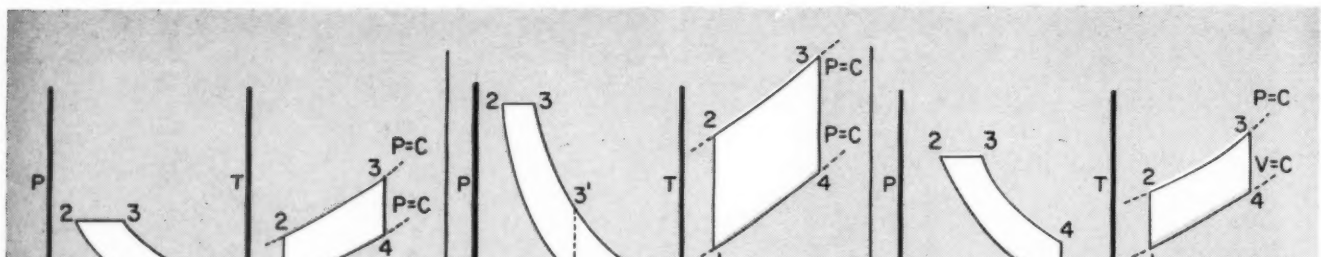
Robert P. Ramsey, presently retained by Cooper-Bessemer as a consulting engineer, deserves considerable credit for American development over the past ten years. Mr. Ramsey is a "convert" from the straight crankshaft engine to the free piston design. He has been one of the pioneer exponents in favor of the commercial development of the free piston engine and its wide application.

Design

The free piston engine seems to be, in engineering circles at least, one of those things that everyone is talking about but no one understands. Even at the recent meeting of the American Society of Mechanical Engineers, in Columbus, Ohio, where several papers were presented on the subject, the audience seemed to be divided into two distinct groups—the experts who knew "more than the speakers," and the audience in general, whose most frequent comment was, "But how does the thing work?"

Actually, the design is quite simple. Two opposing pistons operate in a power cylinder. Each of these connects with another piston of larger diameter at each end. These larger pistons operate as air compressors. Extending further from the compressor pistons are pistons of smaller diameter operating in air cushion cylinders. These are called bounce pistons (see cut-away drawing).

Fuel is injected between the two small power pistons in the power cylinder. When the fuel is exploded, the two power pistons are forced outward, moving both the air compressor pistons and the bounce pistons. The compressed air is directed so that it scavenges the power cylinder and then passes out of the engine—usually going on to a gas turbine. Air is also compressed in the air cushion cylinder by the bounce piston, and this is built up to such a pressure that it forces the pistons inward again so that another stroke is begun. The basic idea is that instead of using a crankshaft and flywheel to return the power pistons on their compression stroke, the job is done by the highly compressed air in the air cushion working against the bounce piston. The length of the stroke is not constant but



THE FPGG (FREE PISTON-GAS GENERATOR) TURBINE COMBINES THE GAS TURBINE AND DIESEL STANDARD CYCLES.

varies with the amount of fuel being burned and the air pressure in the air cushion.

The engine can produce work in several ways. It can be used simply as an air compressor, with only a small part of the compressed air being used to scavenge the power cylinder. However, when used as a prime mover, all the exhaust gases and the compressed air go directly from the engine to the gas turbine.

Current Development

The French SIGMA (Societe Industrielle Generale de Mecanique Applique) has free piston units, in both compressor and gas generator designs, on the market. Over 1000 of their units, operating only as compressors, are now used in industrial applications not only in Europe but also in Africa, South America, Central America, and Mexico. SIGMA has issued licenses to the Allan Muntz organization to manufacture their compressors in England. And since the Junkers free piston compressor was used in German and Japanese submarines, it is reasonable to assume that there has been development work done in both of these countries.

Why has most of the work in this field in the United States been undertaken by only two companies? Lack of interest on the part of most U. S. engine builders has been attributed to conservatism and to the absence of basic information. The design of the engines from a theoretical point of view is quite complex, for dynamic and thermodynamic considerations are closely allied. The American engine designer is not accustomed to dealing with thermodynamics in engine design other than to select a mean effective pressure to establish the necessary piston displacement. The remainder of the design is based primarily upon mechanical considerations. A free piston engine cannot be designed in this way. Thermodynamic and dynamic considerations cannot be separated, and American designers are simply not accustomed to thinking along this line. They have, in most instances, continued to load engines more heavily and progressively to increase mean effective pressures and speeds. Also in an engineering group concentrating upon mass production, there is a tendency to progress by gradual improvement of accepted designs rather than to make sudden changes in basic principles. As one U. S. manufacturer put it, "We like to know where our pistons are—we don't want them floating around loose."

There has been an enormous amount of development work done in this country on gas turbines, but generally speaking the turbine people look upon piston engines as something below them. Perhaps for these reasons, the free piston engine, which uses a gas turbine to provide rotating power, has by its very nature received too little consideration from either the American piston engine designers or the American gas turbine experts. In any event, there is no question but that European manufacturers are well ahead of us in current commercial application of both the compressor and the free piston-gas turbine.

Advantages of Free Piston Cycle

There are two principal advantages of the free piston-gas turbine. The first is its simplicity of mechanical design which gives it an advantage over the conventional diesel engine. The second advantage is thermodynamic. Its theoretical efficiency is much higher than that of the simple gas turbine.

For any such heat engine, the Brayton cycle provides the basis for comparison:

$$\text{Limiting Thermal Efficiency} = 1 - \left(\frac{P_1}{P_2}\right)^{\left(\frac{K-1}{K}\right)}$$

where P_1 is the initial pressure before compression, and P_2 is the pressure at which combustion takes place, and K is the ratio of specific heat at constant pressure to specific heat at constant volume. If this relationship is applied to a supercharged diesel engine, it will be found that the limiting thermal efficiency is from 40 to 65 percent. While the free

piston engine operates on a diesel cycle, it does not have a fixed compression ratio. Combustion may take place throughout a wide range of piston strokes, depending upon the adjustment of a pneumatic pressure regulating valve in the air cushion cylinder. This means that the free piston can attain a pressure ratio over atmospheric as high as 100 to 1 —which gives an ideal Brayton cycle efficiency of 69.7 percent.

Comparison with an open cycle gas turbine of conventional design is even more impressive. Here the pressure ratio is only about six times atmosphere, providing an ideal Brayton cycle efficiency of about 37.2 percent. Of course, actual engines will seldom achieve more than half of these efficiency values because of friction, throttling, and other factors. The basic point is that in the free piston engine and in the supercharged diesel, the pressure ratios are high while with the simple gas turbine the ratio is quite low.

Furthermore, the simple open cycle gas turbine does not lend itself to a very great increase in efficiency through improved designs or materials. Better materials would make it possible to increase operating temperatures but not operating pressures. It is currently believed by a great many engineers that the efficiency of the open cycle gas turbine will be improved greatly as we find metals which will withstand higher operating temperatures. While there will be some efficiency increase because of higher temperatures, the temperature is not nearly as important as the compression ratio. For example, an increase from 1550 F to 1800 F in an open cycle gas turbine would merely increase the efficiency from about 17 percent to about 18.5 percent.

It has been pointed out that the operating temperature of a gas turbine would have to be increased to approximately 3500 F and its compression ratio increased from 6 to 1 to about 100 to 1 in order for its ideal efficiency to equal that of the free piston-gas turbine cycle operating at a conservative 1000 F turbine inlet temperature. Only the more complex turbine plants with axial compressors, intercooling, regeneration, reheat, and high and low pressure turbines could be expected to approach the efficiency of the 1000 F free piston plant.

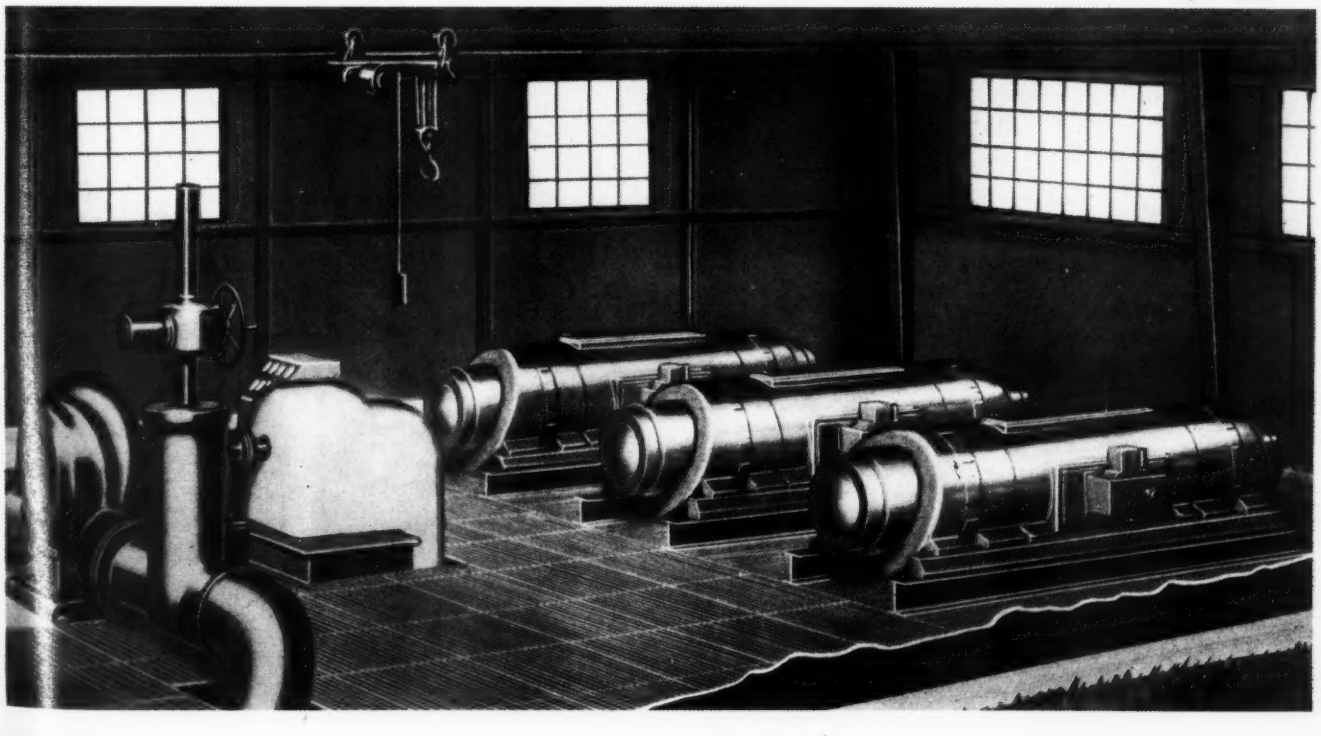
The free piston engine takes advantage of the reciprocating engine design to provide a high pressure rather than a high temperature gas to operate a turbine. The result is a much higher limiting thermal efficiency than can be obtained with high temperatures and relatively low pressures.

Commercial Competition

In the comparisons, 1000 F was used as an operating temperature for exhaust gases entering the turbine from the free piston engine. The free piston generator lends itself to supercharging, and when operated at 1200 F and supercharged, its horsepower output is nearly doubled. On this basis, the free piston unit would seem to be commercially

THREE FREE PISTON GAS GENERATORS EXHAUST TO A GAS TURBINE TO DRIVE PUMPING STATION COMPRESSOR.

Cooper Bessemer



competitive with both supercharged diesels and simple cycle gas turbines.

The difficulty in making such a broad statement lies in the fact that there is an enormous difference in comparison between theoretical efficiency and actual operating data. It is hard to see how anyone could deny the theoretical advantage of the free piston-gas turbine cycle over that of the simple open cycle turbine. On the other hand, we have had, in this country, considerable operating experience with the open cycle turbine, and we have had practically none with the free piston design. We should await the release of more operating data before assuming that the free piston-gas turbine is by its very nature superior to the open cycle gas turbine.

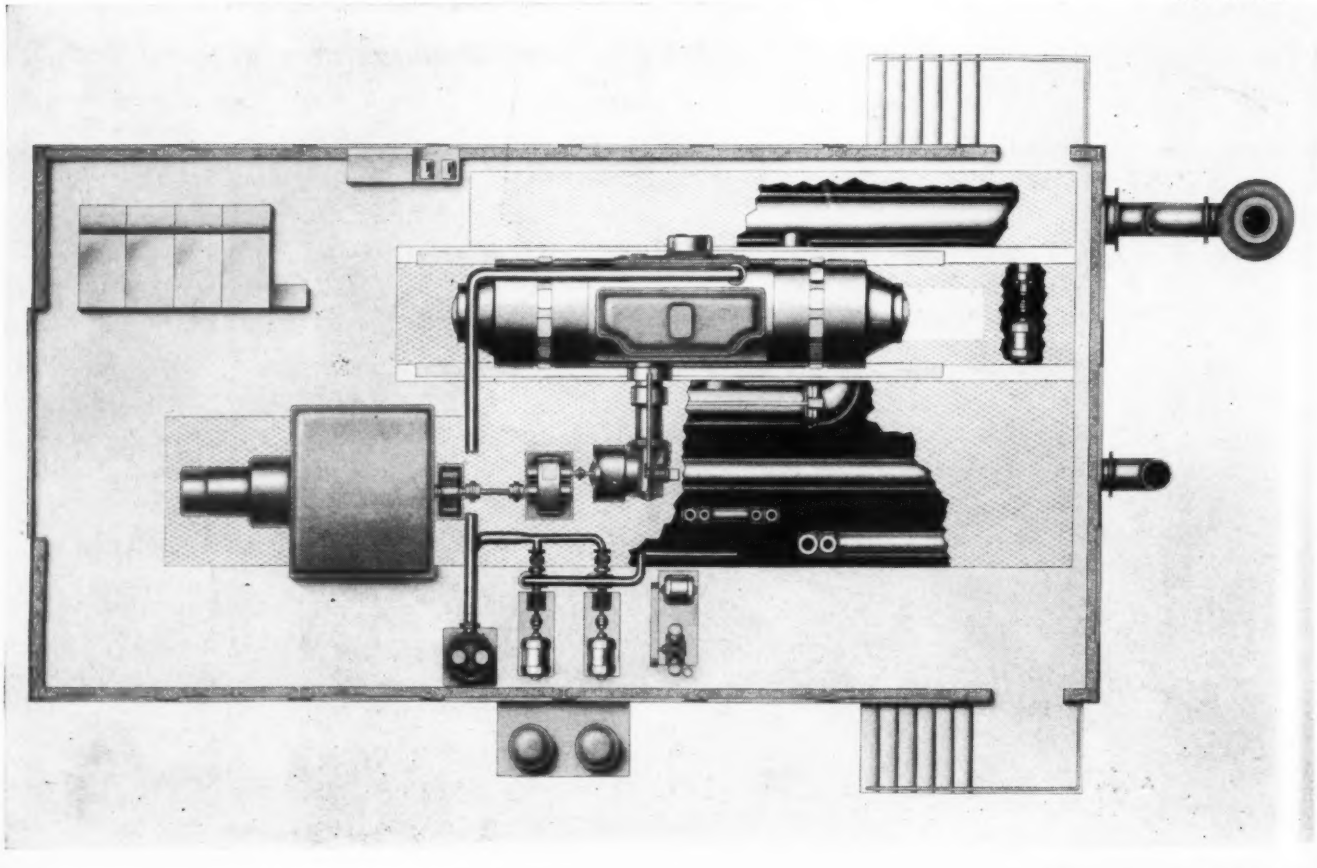
Comparison With Diesel

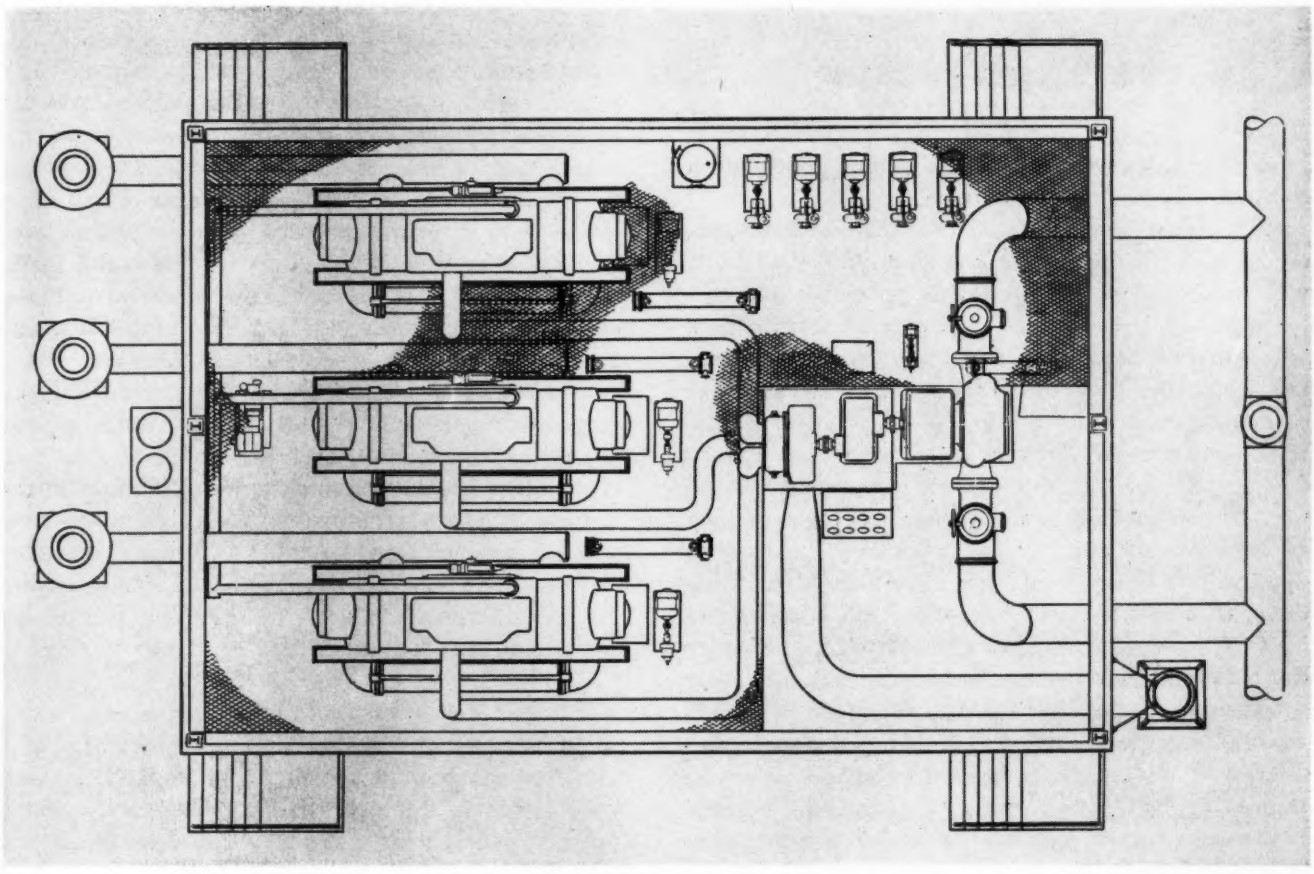
Advantages of free piston design over the conventional diesel are of a different nature. While operating on the same basic diesel cycle, the free piston is of much simpler mechanical design. There are no bearings, crankshafts, or cylinder heads. As a unit it makes use of but one cylinder instead of the combination of cylinders required by a crankshaft engine for dynamic balance. While 70 lb of supercharged pressure would burn out the bearings and break chankshafts of a conventional design, the free piston, having a variable stroke, is easily adjusted to run at whatever compression and firing pressures may be found desirable at the moment. On the Cooper-Bessemer design, the compression pressure is handled directly from the throttle, so that by merely adjusting the flow of fuel, compression and firing pressures are suited to the loads.

Also, this engine runs cooler than most commercial engines now in operation. With 70 lb supercharge pressure, there may be many times the amount of fuel burned in many times the amount of air generally found in a diesel cylinder. The temperature of the pistons should run lower than for conventional diesels because there is approximately 100 percent excess air above the requirements for combustion of the fuel.

Since both the conventional diesel and the free piston operate on the same basic cycle, it would seem that the conventional four-cycle or two-cycle crankshaft engine could be designed to meet these same specifications. Aside from the fact that bearings and cranks would not stand the pressures, such high supercharging would blow most of the air out of the exhaust ports, and even with valve designs which would hold the air in the cylinder, high supercharged pressures would still allow en-

LAYOUT OF AN ELECTRIC GENERATING TEST PLANT MAKING USE OF ONE FREE PISTON ENGINE WITH A GAS TURBINE.
Cooper Bessemer





Cooper Bessemer

FLOOR PLAN FOR THE PUMPING STATION SHOWS PIPING ARRANGEMENT AND OPERATING FLOOR FOR 5000 HP UNIT.

ergy loss through the exhaust and would increase fuel consumption enormously. In the free piston cycle these exhaust gases provide useful work expanding through a gas turbine. In fact, in one particular design, more fuel is added to the free-piston engine exhaust gases before they enter the turbine so that temperatures are increased and the excess air is used in further combustion. The free piston engine compresses and delivers well over 300 percent of the total air required for combustion and this air is blown through the power cylinder to scavenge the hot gases and to cool the metal. This cool air forms an insulator between the hot gases and the piston.

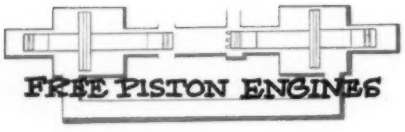
Applications

Unlike the conventional reciprocating engine, the free piston engine when combined with a gas turbine provides the same high speed power take-off as any simple cycle gas turbine. It is a unit which incorporates the smooth rotary turbine power while combining it with the fuel economy of the reciprocating diesel. Furthermore, as is to be expected of a turbine, efficiencies remain at a relatively high level despite variations in load.

This feature of high rotary take-off plus the simplicity of design and the high horsepower-weight ratio would indicate that the free piston-gas turbine should have a number of practical applications.

It was reported four years ago that Baldwin-Lima-Hamilton had submitted plans to the Pennsylvania Railroad for construction of a free piston-gas turbine locomotive, but this does not seem to have developed. At least, neither Baldwin-Lima-Hamilton nor the Pennsylvania Railroad will give any indication of its having been built, or even designed.

The little data available from Europe indicates that the free piston engine can be sold as an air compressor. Also, the SIGMA model GS34 is a complete free piston-gas turbine power plant which is in commercial production. It is now being used in stationary power plant, locomotive, and marine service. These engines are rated at 1310 hp at 600 cycles per minute. They have an exhaust pressure of 50 psig at an exhaust temperature of 945 F. These figures are low in comparison with what an engine of this size (13.4 bore by 17.5 full load stroke) could be expected to do. The U. S. Navy states that this model operates with a maximum gas thermal efficiency of 38.2 percent. This engine has been compared by the Navy with the Baldwin-Lima-Hamilton model B which operates at 1035 cycles per minute and has a rated maximum horsepower of 885. Its exhaust pressure is 90 psig and exhaust temperature is 1295 F. This engine has a smaller bore and stroke, the bore being 8¼ in. and the full load



stroke 11 in. Navy tests give this engine a maximum thermal efficiency of 40.3 percent.

It has been suggested that the free piston engine, as typified by Baldwin-Lima-Hamilton models is well suited to portable electric generator stations, locomotives, truck drives, and special marine uses where weight and space are important. It has been left to Cooper-Bessemer to do the most extensive investigation in this country as to practical industrial applications. They say that the heavy duty free piston gas-turbine power generating station may be competitive in the general base power field as well as for standby, semi-portable, and other applications where foundations are a problem. They claim that their new engine offers space savings of 30 to 60 percent when compared with the heavy duty diesel. They further point out that this same space saving is possible when the free piston installation is compared with the steam turbine plant.

Most of Cooper-Bessemer's efforts have been directed toward three basic applications, electric power generation, pipeline pumping, and ship propulsion. Their design for a power generating station is a 5000 kilowatt unit which includes one alternator, one gear, and one turbine, with three or four gas generators. This basic unit may be applied in multiples. They think that the ultimate limiting size of such a power plant would be determined only by the economics of the specific application and practical experience—the latter of which we now have none. They point out, however, that a multi-unit conventional gas engine plant of 150,000 horsepower is now a reality and larger plants are being planned, so there is no reason the free piston engine could not develop up to this size.

Maitenance

Cooper-Bessemer emphasizes the simplified maintenance to be found in such an installation. They have arranged their engine so that valve gages are on the outside and easily removed. The end cylinders may be lifted back to expose the piston rings and the power cylinder can be taken off with a hoist directly from the top of the generator.

It is in the possible application to pipeline pumping that Cooper-Bessemer seems to have concentrated most. Pipeline booster stations use high speed centrifugal pumps which could be run directly from free piston turbo-engines. Units of 1500 horsepower lend themselves well to parallel operation and this makes possible the use of smaller and less expensive centrifugal pumps and piping. On the other hand, several small engines could be grouped in a battery. However, the current test model is not designed to operate on natural gas, and this handicaps it as a compressor station drive.

Baldwin-Lima-Hamilton (working with the Navy) and SIGMA have already indicated the practicability of applying free piston engines to marine use. Cooper-Bessemer has made a specific study of the application of this drive to a cargo vessel. They claim that it would provide reliability and high thermal efficiency with reduced weight and space requirements. It also should have a low installation cost and low maintenance. Another important feature is the absence of mechanical vibration which would be an important design feature not only on ships but where only light foundations can be used or where equipment must be mobile. In connection with vibration, there was on exhibition at the Leipzig Fair, in Germany, in 1938 a free piston compressor, hanging from a single cable, which operated with so little vibration that a pencil was balanced on the machine while it was running at full capacity and speed.

Conclusions

Today, the free piston design is standing at a peculiar phase of its development. I. B. T. Babbitt patented it in this country in 1868. Pescara developed it in comparative secrecy in Europe after World War I. One of the first descriptions of this machine in American technical literature appeared in *Southern Power Journal* in November, 1932—an article entitled "The Pescara Free Piston Motor-Compressor," authored by a Mr. J. Gould Coutant, a French engineer living in New York. This was followed later by several other articles by Mr. Coutant, also published in *Southern Power Journal* and its successor, *Southern Power and Industry*. Sulzer Brothers of Switzerland studied free piston design as early as 1942, and the German Junkers firm was obviously successful in applying this cycle to the compression of air during World War II. Since the last war, SIGMA of France has built not only compressors but complete free piston-gas turbine units and has applied them to locomotives, power plants, and ships.

In this country, other than Mr. J. Gould Coutant and perhaps some of the readers of his articles, no interest was indicated until after the war when the Navy sponsored Baldwin-Lima-Hamilton in their work. During the past three or four years, several papers have been presented before meetings of the American Society of Mechanical Engineers on various aspects of the foreign and the Baldwin-Lima-Hamilton engines. Then suddenly, within the past few months,—since the Spring Meeting of ASME in Columbus—Cooper-Bessemer has entered the commercial picture with an engine. The major handicap here would seem to be that, to date, they have not reported any customers.

American development in this instance seems to

have been abysmally slow. Perhaps Baldwin-Lima-Hamilton has been held back by Navy restrictions, while American engine manufacturers other than Cooper-Bessemer seem to be sticking to either the conventional diesel or the open cycle gas turbine. Also the Navy's restriction of information and test results has probably had much to do with other manufacturers keeping out of the field.

If Cooper-Bessemer can sell a few engines for ships, pipelines, or power plants, and if Baldwin-Lima-Hamilton can or wants to use their engine for other service than with the Navy, it is quite possible that this country will get back into the picture and that the free piston-gas turbine will become an important prime mover in this country and throughout the world within a relatively few years.

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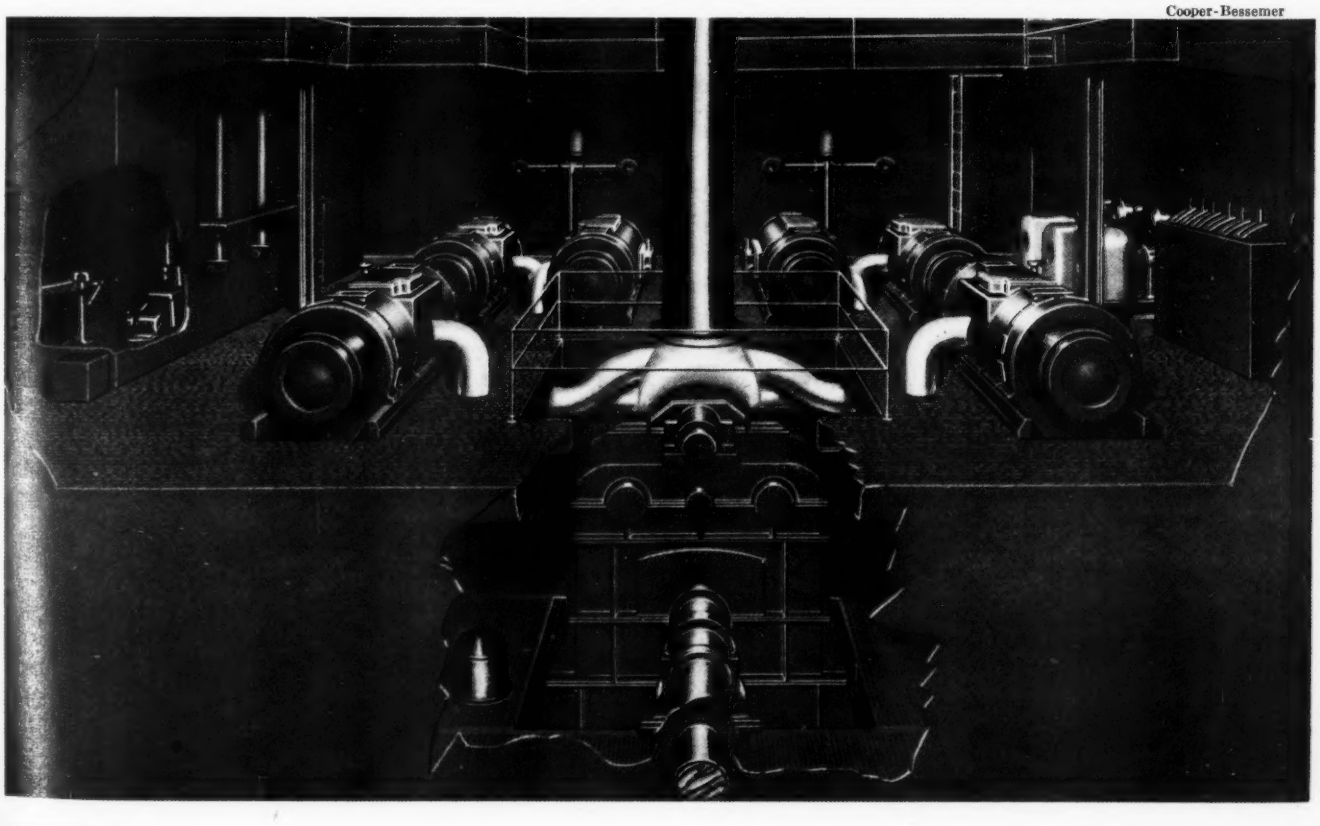
*It is understood that the A.S.M.E. is preparing a booklet combining all the information previously published in its papers on the free piston.

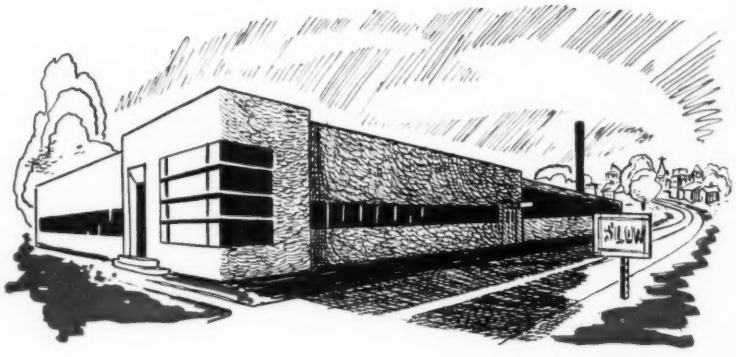
THIS FREE PISTON-GAS TURBINE SHIP DRIVE WOULD COST AN ESTIMATED $158 PER TON AGAINST $180 FOR STEAM.

Cooper-Bessemer



States Enact Legislation To Attract New Industries

AS A GROWING NUMBER of states enact legislation aimed at attracting new industries, the importance of such measures becomes increasingly apparent in the selection of industrial plant sites. Legislation of this type may take the form of municipal financing, easement of private credit, creation of agencies to attract new industries, or tax concessions.



Although the subject of much criticism from investment bankers and others concerned with municipal credit, a trend of recent years has been toward direct or indirect use of local government credit in the financing of industrial plant facilities for lease to private industries. A bill recently enacted by the Nebraska legislature authorizes cities and villages to issue revenue bonds for financing the construction or purchase of buildings for lease to private industries on a self-liquidating basis. The act emphasizes that such bonds are to be payable solely from project revenues, and specifically prohibits any municipality from operating "any manufacturing, industrial, or commercial enterprise."

Tennessee lawmakers authorized counties to issue revenue bonds for the construction of buildings for lease to private industries. Municipalities were given similar authority under a 1951 law.

Other states in which statutory authority exists for the issuance of municipal revenue bonds to finance buildings for lease to private industries include Alabama, Illinois, Kentucky, and Pennsylvania, while Louisiana and Mississippi permit issuance of general obligation bonds for such purposes.

Private Credit

Seeking to foster industrial development through private rather than public credit, Connecticut lawmakers enacted a bill authorizing the creation of a privately-financed and operated Credit Development Corporation to provide industrial development and expansion credit in instances where it is unavailable through normal banking channels. The corporation will raise money from banks, insurance companies, and other financial institutions in the state and will lend it to business in the state or to industries desiring to come into the state.

Similar enabling legislation was enacted in Rhode Island and Vermont, with the creation of the Rhode Island Development Corp. and the Vermont Development Credit Corp., respectively. Among other provisions, the new Vermont measure amends the state's banking laws to permit banks to pledge 2½ percent of their capital accounts for membership in the development corporation, and to permit them to own common stock of the organization.

The establishment of privately-financed and operated state credit development corporations among the New England states appears to stem from the success of similar laws previously enacted in Maine and New Hampshire. Now pending in Massachusetts and backed by Governor Herter is a similar bill which, if enacted, would make this type of legislation unanimous among the New England states.

Agencies

Meanwhile, the Massachusetts lawmakers enacted a bill creating a new separate State Department of Commerce whose primary objective will be to develop fully the commercial and industrial resources of the state. Another bill enacted in Massachusetts provides for a legislative interim study of the possibility of establishing a steel mill in the state.

Tennessee's legislature enacted a bill creating a new eight-member State Industrial and Agricultural Development Commission. In addition to a $75,000 state appropriation, the Commission may accept private donations and contributions from municipalities and counties on a five cent per capita basis.

Wisconsin lawmakers created a state legislative interim committee to study industrial development. Given a $10,000 appropriation, the committee was directed to inquire into factors both favorable and

(Continued on page 68)

THIS AREA IS REPRESENTATIVE OF THE KIND SUITED TO THE LIGHT-DUTY OVERHEAD SECONDARY NETWORK SYSTEM.

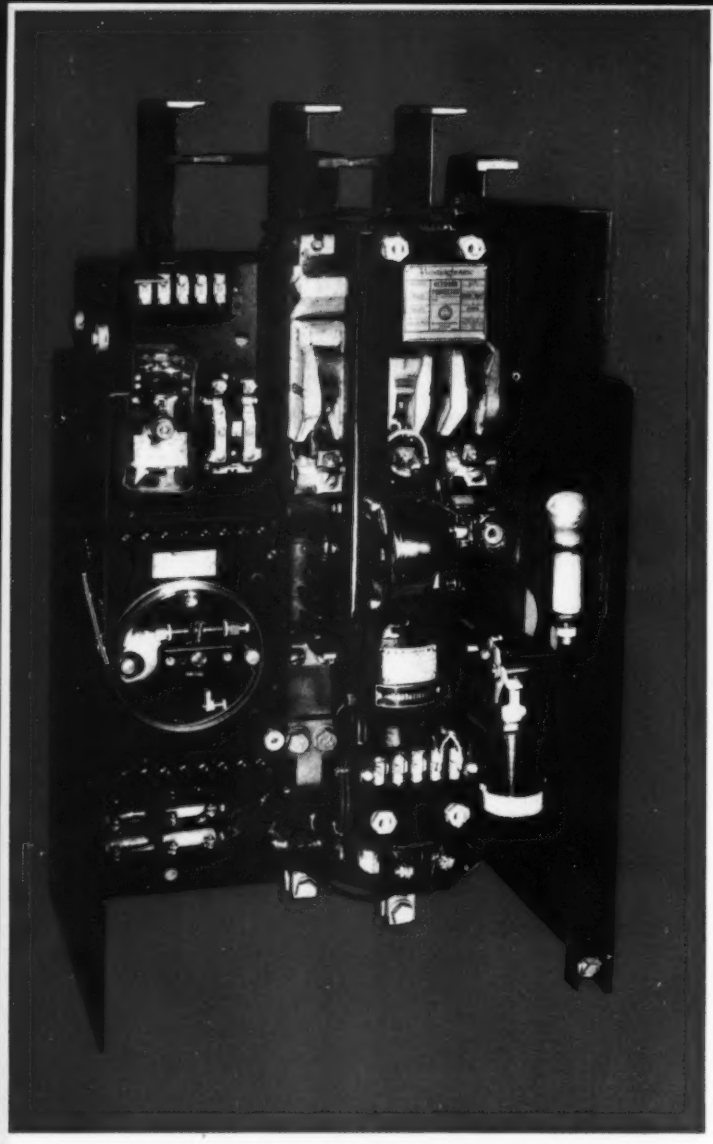
Light-Duty Overhead Networks

H. G. BARNETT, H. B. THACKER, AND R. A. ZIMMERMAN
Westinghouse Electric Corporation

The application of secondary network distribution to light-duty overhead systems is desirable from many economic and operating points of view. In small towns and outlying suburban areas, load distributions often dictate this system as a wise choice.

LIGHT-DUTY NETWORK systems are designed so that all the services to both power and lighting loads are tapped from a three-phase secondary main. Power is supplied to the loads through several transformers connected to the secondary main through light-duty network protectors. The transformers are supplied by two or more primary feeders with adjacent transformers connected to different feeders.

Ordinarily the load divides among the transformers and between the two feeders. Power can flow to any service over several paths. A suddenly applied load, such as a motor starting current, divides among these paths. This manner of supplying the load pro-



HEART OF SECONDARY NETWORK IS THE NETWORK PROTECTOR, A RELAY-CONTROLLED AIR BREAKER.

vides the worthwhile advantages of the network system over the radial system generally used in most small cities.

When a fault occurs in one of the primary feeders or in a transformer, the fault is automatically isolated from the system and the load is carried, without interruption, by the remaining feeders and transformers. The fault is isolated by the opening of the feeder breaker and the network protectors associated with the fault. This feature of the network system prevents interrupting service to any load when a feeder or transformer fault occurs.

The network protector is an electrically-operated air circuit breaker controlled by network relays. The network relays cause the protector to open automatically when current flows in the wrong direction — that is, from the secondary main to the transformer. When the transformer associated with an open protector is reenergized with proper voltage, the network protector closes automatically. Therefore, when a faulted feeder has been repaired and reenergized with the correct voltage, the corresponding network protectors reclose, and the feeder and its transformers again assume their share of the load.

In the radial system commonly used in small cities and towns, each transformer (and its isolated section of secondary main) supplies an individual load or group of loads. Often there are separate transformers and secondary mains for light and power supplies with two services running to the property of many consumers.

Network Advantages

Compared with the radial system, the light-duty secondary network offers the following advantages:

(a) Takes advantage of the diversity among all the loads in the area;

(b) handles abrupt loads such as motor starting currents without intolerable light flicker;

(c) provides better and more uniform voltages for all consumers;

(d) supplies power and lighting loads from the same secondary mains;

(e) takes care of new loads and load growth more easily;

(f) prevents service interruptions due to faults in a primary feeder or transformer;

(g) permits inspection and maintenance of transformers and network protectors without interrupting service to any loads; and

(h) facilitates neat and orderly overhead construction.

Economic Factors

In terms of the total cost of a distribution system for supplying the business area of a small city or town, the light-duty network system will generally cost little more than an ordinary simple radial system. The actual difference depends in part on the arrangement of the radial system with which the light-duty network system is compared.

Where power and lighting loads are supplied from separate transformer banks, secondary mains, and services, the cost of the network system will be little if any more than the radial system. A simple radial system supplying both power and lighting loads from the same secondary would be somewhat cheaper. In general, the system investment from the bulk power source to the loads will be 10 to 15 percent more for a network system than for a radial system.

A factor in favor of the network system is that it frequently can serve a given load with less transformer capacity than would be possible with a radial system. It seldom is necessary to put more transformer capacity in the network than would be required in a radial system because an outage of one of the feeders will occur infrequently and will be of short duration.

Transformer Loading

Transformers in the light-duty network system can be loaded to about their rated capacity or about

the same as in a radial system. Since the feeders from which the network is supplied are usually overhead open-wire circuits, a fault can be located and repaired quickly. The feeders usually supply other loads radially and will not be interrupted except when a fault occurs. During these infrequent and short feeder outages, the overload capability of the network equipment permits the remaining units to carry the entire load.

Conversion Costs

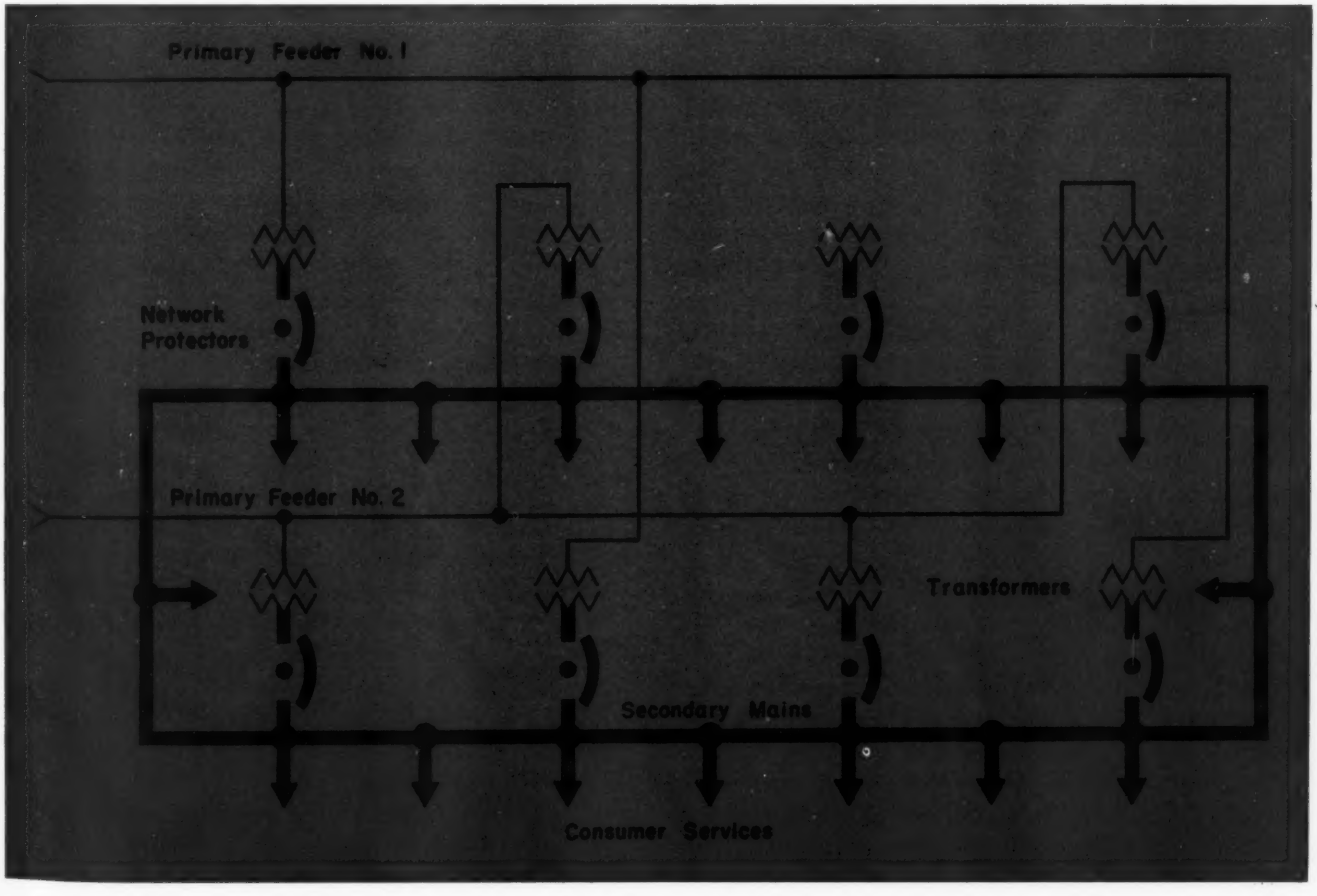
The cost of converting a system to the light-duty network varies between $10 and $30 per kva. This cost depends on the extent to which existing equipment and circuits can be used in the light-duty network system. Where the existing transformers can be used in the network system and the secondary main copper is of suitable size and extent, the cost of adapting the system to network operation will be in the lower end of this range.

In most of the business districts of towns and small cities, the service requirements prevent using the cheapest system available. Reliability, good voltage regulation, and flexibility for expansion of the system are important operating factors which warrant extra expenditure in the distribution system. In addition to these operating factors, there are other economic factors which outweigh the increased cost of secondary switchgear (protectors) when converting from a radial to a network system. Subtransmission circuits often can be carried to the network transformers, eliminating the distribution substation. Duplication can be eliminated of secondary copper, primary feeders, subtransmission lines, and associated switchgear required in radial systems to serve light and power loads.

Load Density

Towns and small cities having a population of two or three thousand or more are likely to have several blocks in the business district where the light-duty overhead network system can provide the advantages of a network at relatively little extra cost. Where the load in these areas is between 60 kva and 300 kva per block or between 125 kva and 600 kva per 1000 feet of secondary main, the light-duty network can distribute power with a high degree of reliability and useful flexibility for load growth.

A light-duty overhead network system will have its longest usefulness when it is applied in an area where the load density is near the lower limit of the above range. A 75-kva network unit can supply loads at that density with one transformer in each block. Then by adding network transformers between the original units and eventually changing to 150-kva units and larger secondaries, a load increase



GENERAL CIRCUIT ARRANGEMENT OF A LIGHT-DUTY OVERHEAD SECONDARY NETWORK DISTRIBUTION SYSTEM.

of at least four to one can be accommodated. This represents a period of 15 to 25 years in most cities. In those places where the load density is already near the top of the range, it is better to consider bigger conventional network units in an overhead network arrangement or conversion to an underground network system.

Favorable Conditions

An existing overhead radial system can be most easily adapted to network operations in those cities where the heavy-load-density area consists of two or more blocks on each side of a main street with alleys through the blocks parallel to the street. In this situation, the secondary mains can form a simple loop in the alleys. Where the alleys are not continuous or other circumstances prevent the use of a simple secondary loop, the light-duty network can be used with a grid or a line of secondary mains interconnecting the transformer.

The opportune time for installing a light-duty network is when the existing radial distribution system requires extensive rebuilding and rearranging, and the load is growing and is about 60 kva per block. For little more than the cost of rebuilding, the radial system can be adapted to network operation.

Area Size

The basic operation of the light-duty network can be adapted to extensive areas. However, there are some practical limitations beyond which the use of the light-duty network may be doubtful.

The principal limitation is the amount of load involved. When the total load in an area considered for a light-duty network exceeds the emergency capacity of one feeder, there should be some consideration given to the use of the conventional form of secondary network in which primary feeders are dedicated solely to supplying the secondary network distribution system.

Beyond this load limit it is necessary to use more than two primary feeders for supplying the area; they should not supply other loads outside the network system. The conventional form of network system offers some operating advantages that are probably warranted for areas where the total load is greater than the emergency capacity of one primary feeder circuit.

System Planning

The general procedure for adapting the light-duty network system involves consideration of the loads in the area, the choice of transformer ratings and spacing, the estimation of the division of load among the units, the choice of secondary main conductor size, and the switching and protection at the primary terminals of the transformers. Except for estimating the division of load among the network units and perhaps some rearranging of the units to get a reasonable division, this procedure for installing the network system is little different than that involved in arranging the ordinary simple-radial distribution system.

Load Determination

The amount and location of the loads in the area are the basic information on which the design of any distribution system is developed. Unfortunately, this information is seldom known accurately. It usually is necessary to estimate the loads as accurately as possible. In those places where up-to-date records are kept of load changes and existing loads, the information may be readily available.

Most frequently, the only load information available is the location and rating of distribution transformers. If this information is tempered by good judgment based on the location of known heavy loads and the areas actually served by the transformers, it can serve well for planning a network installation. If known, the primary feeder loading corresponding to the transformers in the area can be used to temper the values of load estimated for the individual transformers.

If the maximum demands at the various services are known, they should be tempered on the basis of the diversity among the loads in the area. If the total primary load corresponding to the sum of the individual service demands is known, the diversity factor can be readily determined. In many cases, however, it will be necessary to estimate the diversity among the various known demands. The diversity factor for loads in a business area in a small city or town will fall in the range between 1.5 and 3.

An approximation of the diversity factor is the ratio of the sum of the demands to the aggregate distribution transformer capacity used to supply those demands. While the common secondary main in the network takes advantage of the diversity among all of the loads in the area, it does not utilize all of the diversity. It probably will serve in most cases to estimate the total demand on the network units on the basis of utilizing about half of the diversity among all of the services.

Future Growth

The loads on which the arrangement of the light-duty network application is based should include some allowance for future growth. While the network system can be easily expanded, and capacity can be increased conveniently, there should be enough spare capacity to allow for load growth.

The rate of load growth should be determined on the basis of past experience for the particular locality being considered. The network should be designed to supply at least a fourth more load than exists in the area when the system is installed. Usually this allows for three to five years of growth before additional capacity is required.

Understanding Explosions

O. ROBERT SHURIG
General Engineering Laboratory
General Electric Co.

Since 1948, Mr. Shurig has been engaged primarily in technical investigations of safety engineering problems for which knowledge of fundamentals and basic technical data have been lacking. Certainly, the phenomena of explosions fit this category. Prior to his present assignment, Mr. Shurig had been working on engineering investigations and developments in General Electric's general engineering laboratory. From 1941 to 1945, he was administrative officer of the Ballistic Research Laboratory at Aberdeen Proving Ground. Before joining the military, Mr. Shurig had been associated with General Electric 24 years.

National Fire Protection Assn.

LOW-ORDER EXPLOSION OF VAPOR FROM LEAKING GASOLINE WRECKED JET ENGINE TESTING BUILDING.

MUCH OF THE WORK in the operation of pilot plants involves new materials or new processes. To do such work safely, the persons concerned must understand the character of the materials and processes, the explosion hazards that may be encountered, and the means for avoiding them. Such projects often call for the solution of new engineering problems relating to safety—problems for which the answers are not readily available.

A problem which has grown in importance is that of determining the requirements for enclosures or barricades to resist accidental explosions that may occur, for example, in development work using high-energy fuels, in combustion investigations, or in the preparation and use of modern propellants.

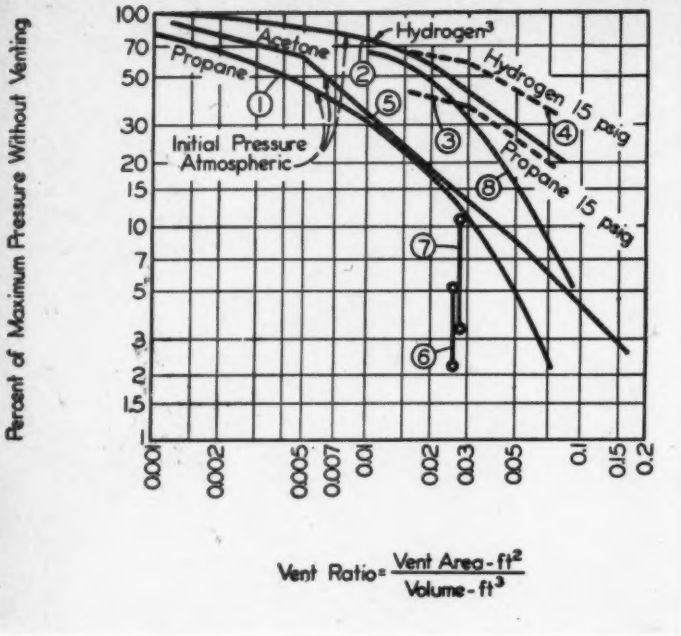
The design of a structure to resist an explosion may, of course, be based on the design of an existing structure which has withstood a similar kind of explosion. This procedure is effective when conditions are similar, but may not be safe when the quantity and type of explosive or the dimensions of the structure are materially changed.

Tests of a sample structure may also be made by exposing it to explosions of the kind that might occur. This was done, for example, by the U. S. Army Corps of Engineers, to help in establishing the ability of different kinds of shelters to resist nearby bomb explosions. While this test procedure is capable of giving valuable data, tests of sample structures for a particular design job are often not practical.

The structural engineer who is given the job of designing a structure to resist an explosion will usually ask for the loads applied to the walls and ceiling. Moreover, he prefers figures for static loads. Since there are no available data on the actual forces or loads applied to the walls of full-size structures during different kinds of explosions, he must study explosion pressure in confined areas, the maximum pressure attained, the manner in which the pressure rises to its peak and falls off thereafter, and the effect vent openings have on these variables.

Low-Order Explosions

A low-order explosion is one for which the velocity of flame travel is well below the velocity of sound, usually in the range from less than 10 to about 100 feet per second. Many of the common gas and vapor explosions are in this category—hydrogen, natural



VENTING EFFECTS ON PRESSURE FOR LOW-ORDER EXPLOSIONS IN ENCLOSED SPACES. CURVES SHOW EFFECTS FROM MIXTURES IGNITED AT ATMOSPHERIC PRESSURE EXCEPT WHERE NOTED OTHERWISE:

(1) Mixture of 5 percent propane in air, open vents; maximum rate of pressure rise is 2000 psi per sec.

(2) Mixture of 40 percent hydrogen in air, open vents; maximum rate of pressure rise is 9000 psi per sec.

(3) Mixture of 5 percent propane in air, ignited at 15 psig.

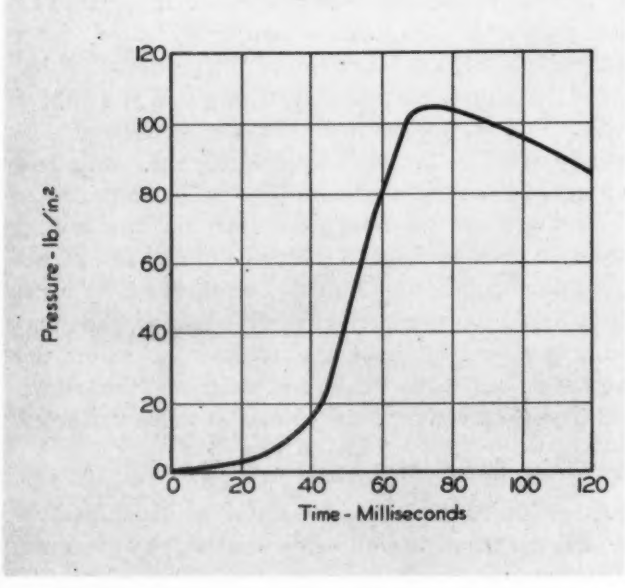
(4) Mixture of 40 percent hydrogen in air, ignited at 15 psig.

(5) Mixture of 5.5 percent acetone in air.

(6) Coal dust 0.20 oz per ft³ in air, paper or fabric covered vent; maximum rate of pressure rise 1100 psi per sec.

(7) Aluminum dust 0.025 oz per ft³ in air, paper or fabric covered vents.

(8) Cornstarch in air, open vents.



PRESSURE-TIME CURVE FOR AN EXPLOSION IN A CLOSED CHAMBER OF 2.3 PERCENT GASOLINE IN AIR.

gas, manufactured gas, gasoline, acetylene, and various solvents. Dust explosions are also in this class. The damage from low-order explosions in enclosures is largely due to the pressure rise resulting from the hot gases. The low flame speeds are in contrast to detonation velocities faster than the velocity of sound, obtained during detonations in piping systems and with high-order explosives.

Table 1 shows peak pressure values for explosions of the more common gases and vapors in air in closed chambers. The maximum pressure is from about 60 to over 160 psig when the initial pressure is atmospheric; the absolute peak pressure is about 5 to 12 times the initial absolute pressure.

Although a majority of the pressure values shown are above 100 psig, a structure which is required to resist an explosion of one of these gases need not be built to withstand the maximum pressure shown, provided the space is adequately vented. Structures would be very expensive indeed if they had to resist a pressure of over 100 psig. Ordinary wall panels used in laboratories will not withstand anything like this pressure, and relatively few structures are capable of resisting an explosion pressure of even one-tenth of this amount without damage.

According to British reports on World War II damage from bombs, most brick walls (at least 12-in. thick) withstood a bomb blast impulse having a peak pressure of 6.5 psig except walls of interior courts or rooms. Similarly, from the Japanese air-blast damage experience of the atom bomb, a blast of 7.4 psig peak pressure severely cracked 12-in. brick walls, destroyed a steel frame building and caused the collapse of light concrete buildings. The impulse exerted by the atomic-bomb blast considered here is materially greater than the impulse due to a TNT bomb blast having the same peak pressure value, and therefore is capable of producing greater structural damage, especially for structures of low natural frequency.

Vents and Pressure Magnitude

Why and under what conditions do vents reduce the maximum explosion pressure? An explosion-pressure vs. time curve for a mixture of 2.3 percent gasoline vapor and air in a closed chamber shows the principal pressure rise takes place over a period of approximately 20-30 milliseconds. The time interval while the pressure is rising is sufficient to permit some of the gas to escape through any vent opening provided in the enclosure. The maximum pressure will therefore be lower in a vented enclosure than in an unvented one for low-order explosions, depending on the rate of pressure rise during the combustion reaction and depending on the size of the vent opening in relation to the volume of the room.

The pressure reduction by vents can be correlated with the velocity of flame propagation, or with the maximum rate of pressure rise measured in a closed-

chamber explosion. For example, the explosions of hydrogen, propane, and coal dust have maximum rates of pressure rise approximately 9000, 2000, and 1100 psi per second respectively, indicating an increased venting effect as the maximum rate of pressure rise, or the rate of reaction, diminishes.

TABLE 1—EXPLOSION PRESSURE FOR VARIOUS FLAMMABLE VAPORS AND GASES IN AIR IN CLOSED CHAMBERS

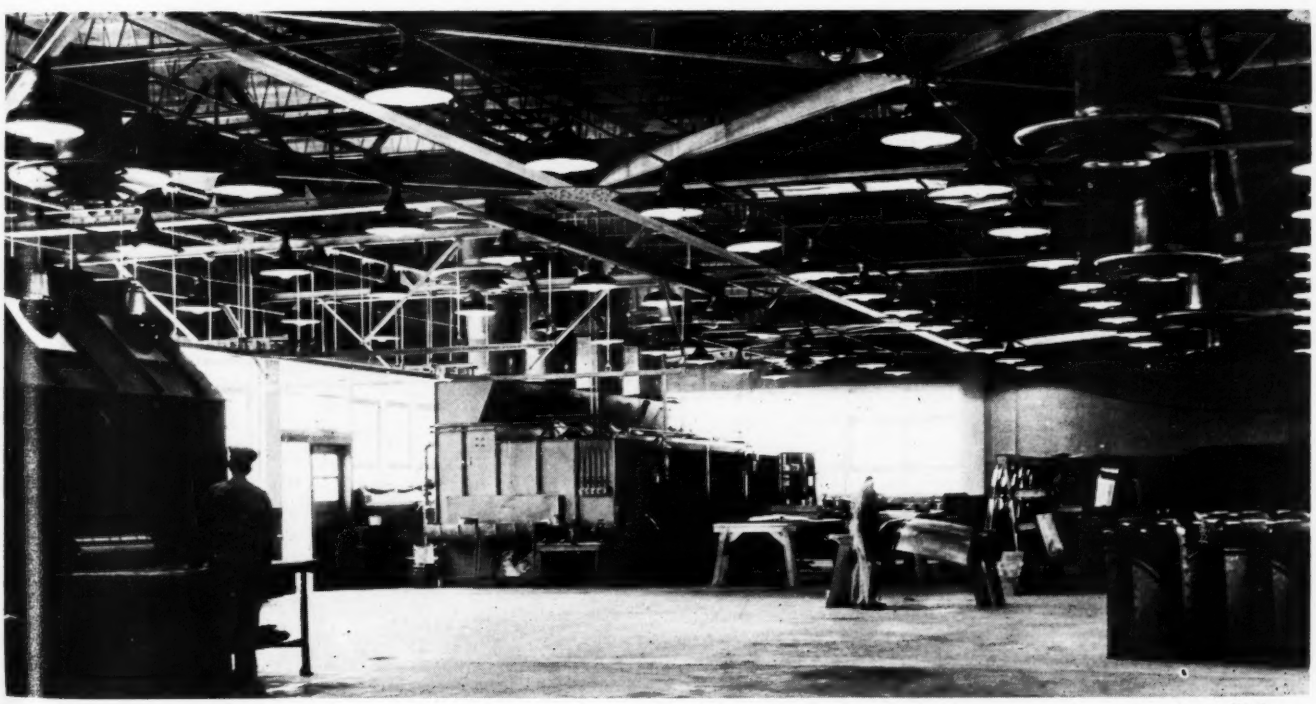
Gas or vapor	Max pressure psig	Ratio max abs pressure / initial abs pressure	Vessel volume cu ft	Ratio L/D*
		Initial pressure — atmospheric		
Hydrogen	96	7.5	—	—
Hydrogen	102	8.0	7.6	1.44
Hydrogen	74	6.1	3.0	2.30
Methane	102	8.0	0.57	Sphere
Methane	109	8.4	0.14	Sphere
Methane	59	5.0	0.57	20
Methane	94	7.4	0.14	Sphere
Ethane	102	7.9	0.14	Sphere
Propane	104	8.1	0.14	Sphere
Propane	90	7.1	3.0	2.3
Butane	110	8.5	0.14	Sphere
Pentane	115	8.85	0.14	Sphere
Acetylene	162	12.0	—	—
Mfrd fuel gas	110	8.5	—	—
Mfrd fuel gas	94	7.4	0.28	9.5
Gasoline	105	8.2	—	—
Gasoline	135	10.2	Calculation	
Acetone	78	6.4	0.28	9.5
		Initial pressure — 15 psig		
Hydrogen	198	7.2	1.13	1.54
Propane	220	7.9	1.13	1.54
		Initial pressure — 45 psig		
Hydrogen	417	7.2	1.13	1.54
Propane	489	8.5	1.13	1.54

*Ratio of length of vessel to diameter

Explosion Impulse

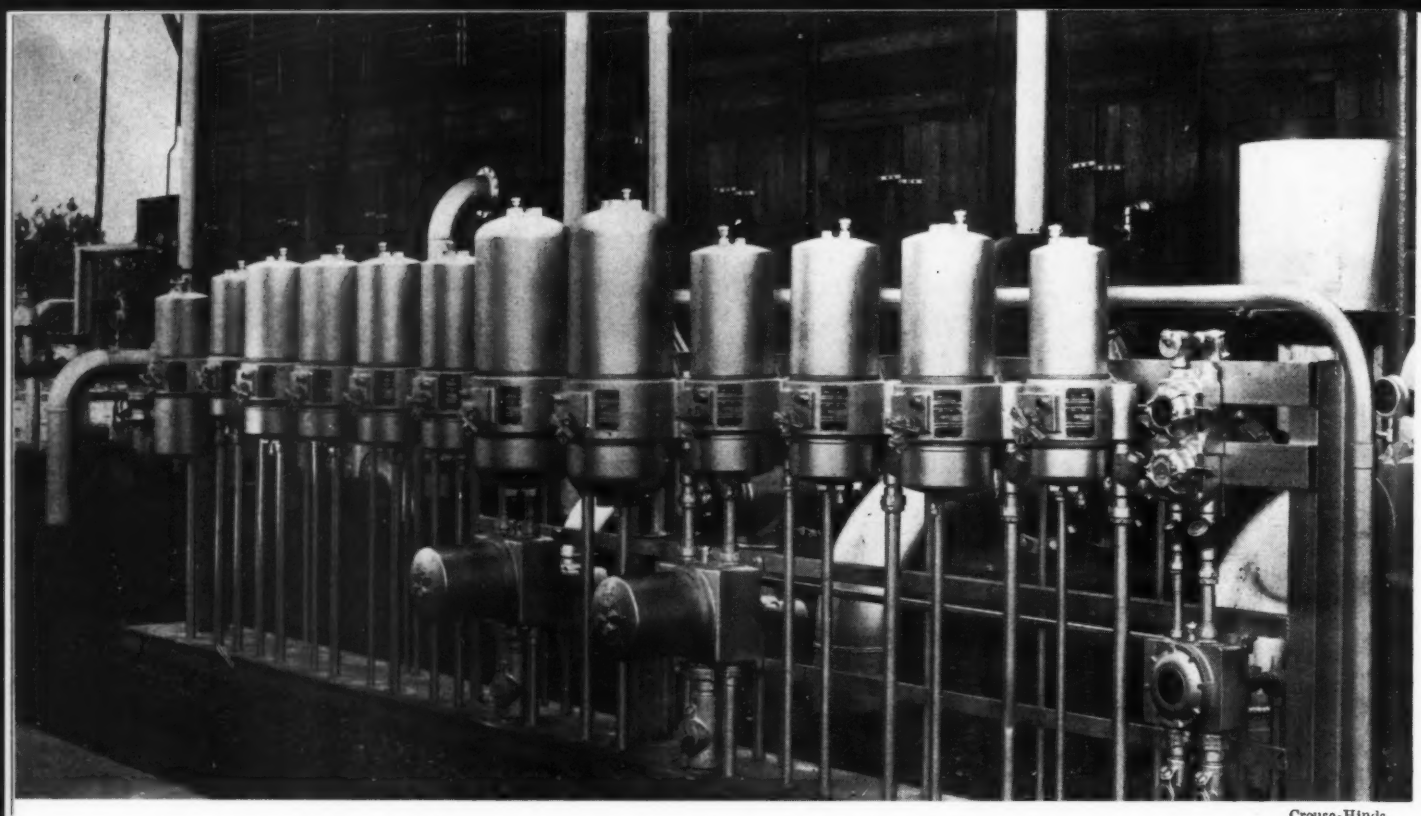
The maximum explosion pressure for a vented area does not fully define the true explosion load imposed on the walls of an enclosure because a given force applied to a wall panel for a long period may be more destructive than the same force applied for a short period. Moreover, the explosion pressure is not constant. The duration and shape of the pressure-time curve for explosions in vented rooms determines the impulse exerted, and hence the dynamic effect of an explosion on a structure. By definition, the impulse is the area under the pressure-time curve. The actual impulse may often be represented by a triangle, or by the area under an exponentially decaying curve, or even approximately by a rectangular impulse using the average force.

An instrument has been devised which indicates,



Crouse-Hinds

EXPLOSION-PROOF LIGHTING FIXTURES FOR GENERAL INDUSTRIAL ILLUMINATION REDUCE IGNITION HAZARDS.



Crouse-Hinds

A POTENTIALLY HAZARDOUS PETROLEUM REFINERY INSURES SAFETY BY MAKING THIS MOTOR CONTROL CENTER OF EXPLOSION-PROOF EQUIPMENT INCLUDING MOTOR STARTERS, CIRCUIT BREAKERS, JUNCTION BOXES AND SEALS.

for an explosion in an enclosure, a deflection equal to that of a typical 12-in. industrial brick wall exposed to the same explosion impulse, within the elastic limit of the wall structure. The instrument has a natural frequency of seven cycles per second, equal to that of the brick wall represented. Moreover, the maximum deflection of the wall when loaded to its elastic limit has been determined by separate investigations. Thus it can be determined by non-destructive explosion-chamber tests whether a particular explosion will result in a wall deflection above or below the elastic limit for the wall which the instrument represents.

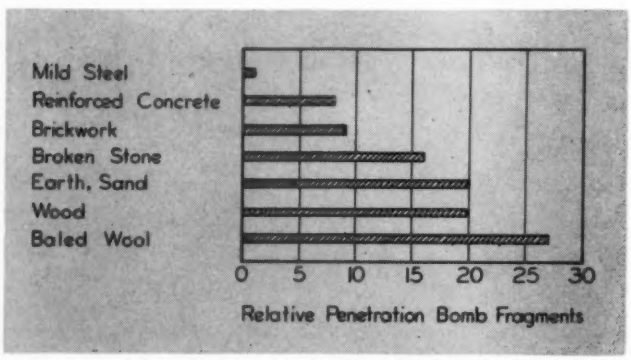
Equivalent Static Load

How can pressure and impulse data for an explosion be used to obtain an equivalent static pressure for the purpose of designing a structural element such as a wall? The static pressure load sought is of such a magnitude and distribution that the wall will be stressed to the same degree under the static loading as under the impulse. Then the equivalent static load will be the pressure which causes the same deflection at every point of the wall as the explosion impulse, provided the elastic limit of the wall material is not exceeded. (In designing structures to resist explosion impulses, it is believed that the elastic limit should not be exceeded when the safety of personnel has to be considered, because of the damage done to structures loaded beyond the elastic limit.)

The advantage to be gained by using the equivalent static pressure is that it permits using conventional static-load methods in designing structures, instead of requiring a more complicated dynamical analysis.

The determination of the equivalent static load on a structural element, such as a wall panel, involves an analysis of the dynamic displacement and vibration of the panel when a varying pressure is applied to its surface. The analysis would be quite complex if it could not be simplified for engineering calculations.

It has been shown that in the vibration of rigidly supported busbars under suddenly applied short-circuit forces, only one natural frequency needs to be considered. By analogy, it seems reasonable to expect that a plain, uniform wall panel, which is not broken up by ribs or other discontinuities, will deflect in its normal mode, i. e. at its fundamental



FRAGMENTS FROM EXPLODING STEEL BOMB PENETRATE DIFFERENT MATERIALS TO VARYING DEPTHS.

frequency. Furthermore, higher frequencies may be neglected, at least for the rates of pressure rise expected during low-order explosions.

For a structural element that responds to an explosion impulse in the fundamental mode of vibration, the equivalent static load may be determined by the methods of mechanics, at least for some of the simpler shapes of pressure-time curve (such as exponential, rectangular, and triangular). Equivalent static load on a structural element can be shown to be dependent on its natural frequency, on the maximum impulse pressure distributed over the element, and on the duration of the impulse.

The fundamental frequency of vibration for some of the more common types of structural panels may be calculated. However, in view of the meager data on impulse pressure magnitude and the lack of data on impulse duration for explosions in vented enclosures, only approximate calculations of equivalent static load can be made.

The problem of determining the maximum load—preferably expressed as the equivalent static pressure— applied to a wall or other structural element during an explosion is a subject of safety engineering of which further studies need to be made.

High-Order Explosions

A high-order explosion is one in which the reaction during the explosion is propagated through the charge at the rate of a shock wave (detonation wave). Materials capable of high-order explosions include mixtures of hydrogen peroxide with certain fuels, other high-energy propellants, and a variety of military explosives.

Because of the extremely high-speed reactions, very hot gases are immediately formed in a restricted space at a high pressure, resulting in the rapid expansion of the gases and the initiation of a pressure wave (shock wave or blast wave) which is propagated into the surrounding space. The damage done by this type of explosion in an enclosure is due to the shock waves and their reflections striking the walls in quick succession as well as by the gases pushing outward. Information on the magnitude and distribution of pressure and impulse over the wall surfaces of enclosures for high-order explosions is lacking. However, pressure-time curves for similar explosions in the open air have been recorded.

A pressure-time curve for a high-order explosion in a room differs from that for a low-order explosion in two principal respects, namely:

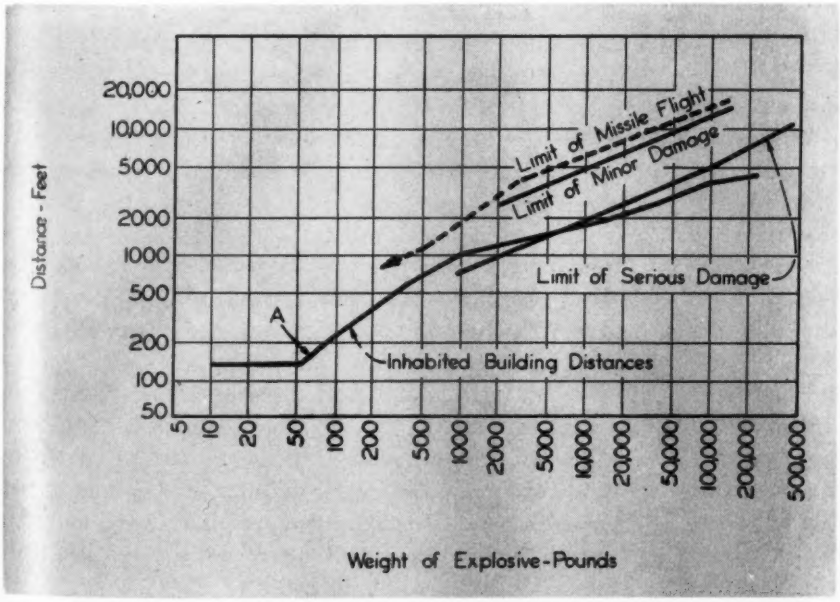
(a) The time interval of pressure rise for a high-order explosion will be a small fraction of that for a low-order explosion.

(b) The high-order explosion will have sharp pressure peaks rising above the average level of pressure, while the low-order explosion will not have such peaks.

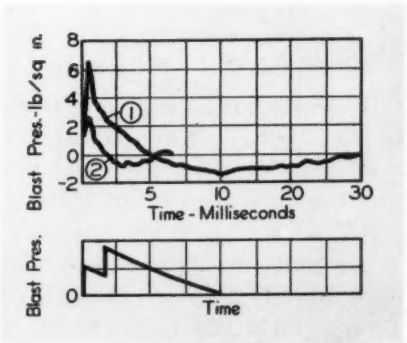
It is to be expected that the initial pressure exerted on the walls of a room during a high-order explosion will not diminish materially with increasing vent area within the range of vent ratios generally used.

To provide data for a practical solution of the problem of predicting stresses in wall members exposed to impulses from high-order explosions and to obtain confirmation of the effects, further data are needed:

(a) Pressure-time curves for high-order explosions in vented enclosures; wall pressure values



FLIGHT AND DAMAGE CURVES ARE BASED ON 125 HIGH-ORDER EXPLOSIONS OVER 100-YEAR PERIOD. CURVE A IS DRAWN FOR UNBARRICADED AREAS.



UPPER SET OF CURVES SHOWS BLAST PRESSURES IN FREE AIR 50 FT FROM EXPLODING 500-LB BOMB (1) AND 6 FT FROM 0.088 LB OF EXPLODING HIGH EXPLOSIVE (2). LOWER CURVE SHOWS VARIATION OF BLAST PRESSURE ABOVE EXPLOSION WITH THE LARGER INITIAL SHOCK FOLLOWED BY REFLECTED SHOCK.

are needed as well as data on the distribution of pressure over wall surfaces, especially near the corners of rooms. According to recent theoretical studies, shock-wave reflections near the corners of the room may build up peak pressures several times higher than the initial peak pressure of the explosion shock.

(b) Quantitative information on the destructive effects of sharp pressure peaks rising above the average pressure level; certain high-intensity shocks are known to have shattering effect on concrete walls, causing scabbing (throwing of pieces of concrete from both front and rear faces of the wall). Steel plates have been used to reduce scabbing.

(c) Is the elastic limit of wall structures under dynamic loads greater than the static elastic limit? In a recent publication a tentative figure for the dynamic elastic limit equal to 1.3 times the static elastic limit is given for reinforced concrete, subject to further confirmation.

Fragment Penetration

In work with high-energy propellants and with explosive chemicals, there is also a fragment hazard if the material should explode while confined in a high-strength container. Protection of personnel and property may be provided either by a wall or barricade designed to stop the fragments or by allowing a distance in open space in excess of the fragment range.

The depth of penetration of steel bomb fragments into concrete, wood, earth, and a few other common materials may be approximately predicted based on British data relating to bomb fragments.

The velocity and size of fragments must be determined in each particular case, depending on the type of container exploding, on the velocity of the explosion reaction, and on the energy and volume of gas liberated.

Fragment Range

When fragments are thrown into open space, such as when passing through vents or when explosions are not barricaded, the limit of fragment flight depends on the amount and character of the exploding material as well as on the type of shell enclosing it. Distances have been established to protect surrounding structures against substantial structural damage; the "inhabited building distance" is defined as the most practical distance requirement from the standpoint of relative safety and economics for protection against property damage. Inhabited building distances are the minimum permissible distances between an explosive location and an inhabited building. Inhabited building distances do not protect against glass breakage or injury to personnel from glass breakage. If practicable, greater distances should be used.

The significance of inhabited building distances in relation to the protection afforded to personnel and property may be judged from the following comparisons: the inhabited building distances are substantially the same as the "limits of serious damage" to buildings, they range from about 25 to 50 percent of the "limits of minor damage" to buildings, and range from about 20 to 50 percent of the limits of missile flight. The inhabited building distances do not protect personnel from the reduced building damage that does occur or from the danger of long-range fragments.

Comparable knowledge relative to the striking range of fragments coming from low-order explosions, such as flammable-vapor or gas explosions, is quite limited.

Piping Systems

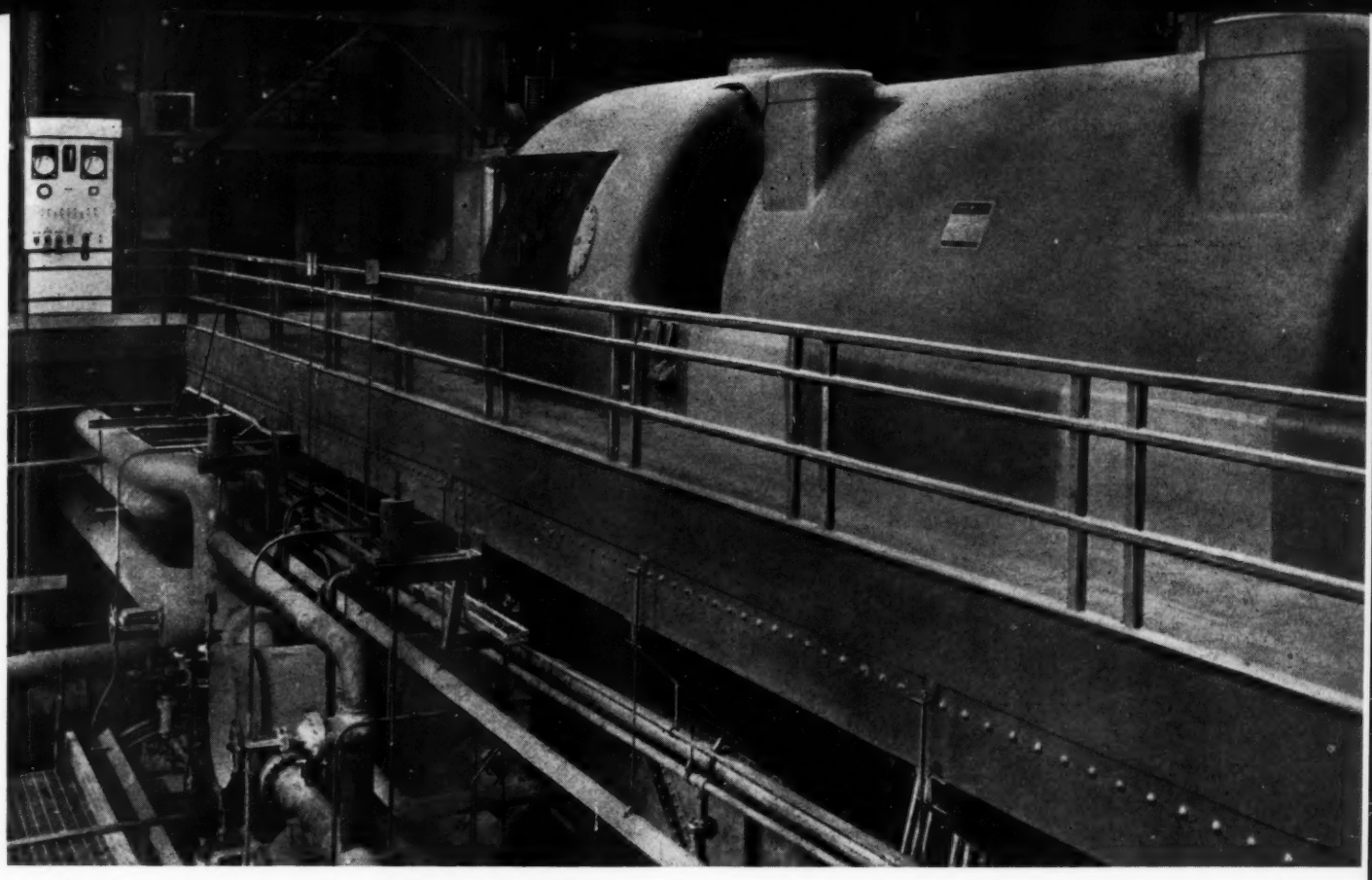
It is well known that some of the ordinarily low-order explosive gas mixtures are capable of detonation when contained in pipes. The velocity of flame propagation then rises well above 1000 feet per second and the maximum pressure obtainable far exceeds that produced in a low-order explosion of the same gas mixture at the same initial pressure. Among the information obtained by numerous investigations of explosive mixture detonations in pipes are many fundamentals:

(a) The minimum length of tube required for a detonation to be set up is roughly proportional to the tube diameter.

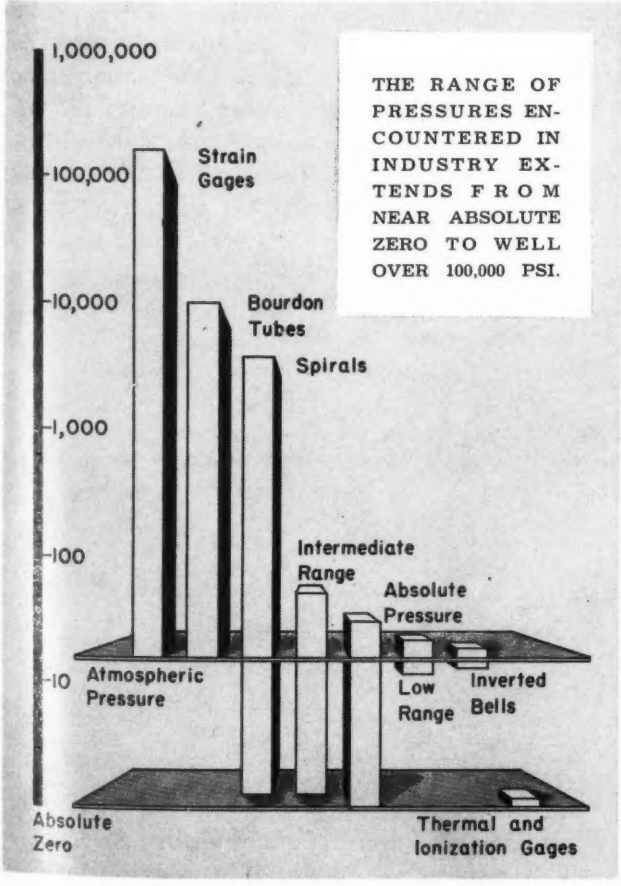
(b) The maximum absolute pressure inferred from the rupture of calibrated bursting discs ranges from less than 100 times to more than 150 times the initial absolute pressure.

(c) The range of gas or vapor content in mixtures for which detonations may occur (the detonation range) is narrower than the range between lower and upper explosive limits for low-order explosions of the same gases. The gases and vapors for which detonations in pipes have been reported include: hydrogen, methane, acetylene, ethylene, ethyl alcohol, ethyl ether, manufactured gas, or gasoline when mixed with air as well as most of these plus carbon monoxide, carbon disulfide, ethane, propane, butane, pentane, or benzene when mixed with oxygen. It has been indicated that the following factors tend to shorten the length within a pipe for establishing a detonation: increasing the initial pressure, introducing discontinuities, and obstructions or roughness in the pipes.

Investigations of detonations of a few flammable gases and vapors in pipes have established some of the basic data relative to the minimum length of tube required to set up a detonation, the maximum pressure and detonation velocity attained, and the effects of pipe diameter and of initial pressure, but the information needs to be extended to cover other gases and vapors, as well as numerous pipe-system design variables and means of protection.



TWO PNEUMATIC PRESSURE TRANSMITTERS SERVE ON THE STARTING PANEL BOARD OF THIS 66,000 KW STEAM TURBINE GENERATOR. ONE MEASUREMENT IS TURBINE THROTTLING PRESSURE, THE OTHER IS THE STEAM PRESSURE IN THE FIRST TURBINE STAGE.



THE RANGE OF PRESSURES ENCOUNTERED IN INDUSTRY EXTENDS FROM NEAR ABSOLUTE ZERO TO WELL OVER 100,000 PSI.

Techniques of Pressure Control

S. D. ROSS
Industrial Division
Minneapolis-Honeywell Regulator Company

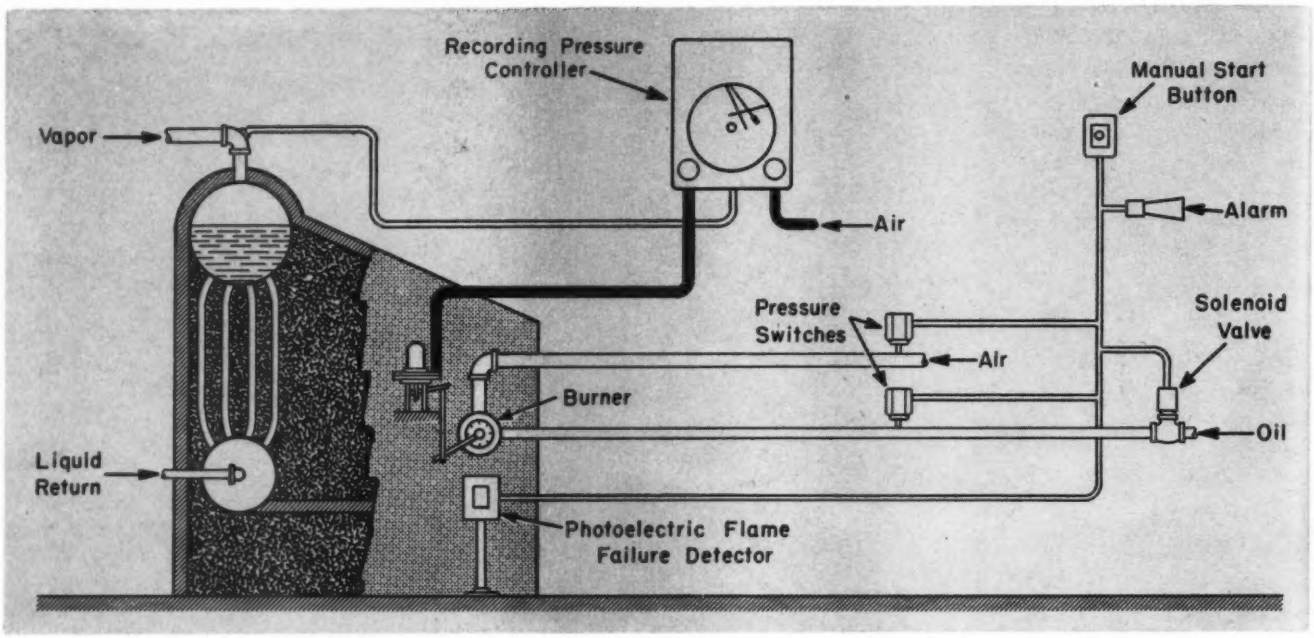
THE NEED for efficient operation in modern industry has extended the ranges of pressure measurement and control upward toward 150,000 psi and downward to 10^{-11} mm of mercury, vacuum. These required extremes have intensified the development of newer types of instrumentation and have stimulated an awareness of their existence by engineers. Demands today for closer control also require several conventional designs of primary elements for intermediate ranges.

Regulators

Common types of industrial regulators may be classified into three groups:

(a) Self-operated and pilot-operated pressure regulating valves.

(b) Mechanical-element-operated controllers of



THIS VAPORIZER SYSTEM USES A PRESSURE CONTROLLER TO GOVERN THE HEAT INPUT TO THE LIQUID-VAPOR SYSTEM BY CONTROL OF THE OIL FEED TO BURNER. INCLUDED IS A FLAME FAILURE SAFETY CONTROL ON OIL FEED.

the non-indicating, indicating, or recording type, employing such elements as the Bourdon tube, spiral, helix, diaphragm, bellows, or inverted bell.

(c) Electrical transducer elements employed with electronic indicating or recording controllers.

Where the difference between two pressures is the critical variable, such as inlet and outlet of a heat exchanger, numerous types of manometers (commonly utilized for flow control) are generally available from manufacturers.

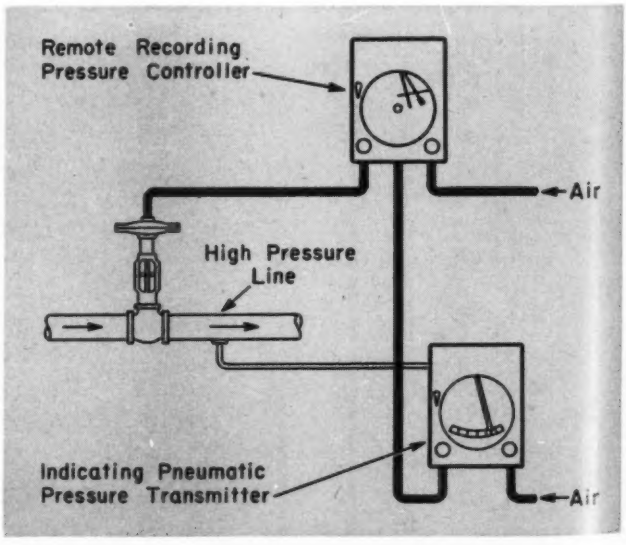
Gas and Vapor Control

In general, the control of pressure in vessels or pipelines is one of the simplest problems of automatic control because most pressure systems have a relatively large capacity. Measurement is usually rather fast, particularly with gases or vapors. Such characteristics make possible the use of a simple, self-operated pressure regulating valve which may be spring-, weight-, or pressure-loaded. The pressure to be regulated is piped to the underside of a diaphragm which is directly connected to the valve stem; the diaphragm is acted upon from above by the loading device such as a spring. The amount of this loading force sets the value of regulated pressure, any deviation of the controlled pressure tending to reposition the valve stem.

For higher operating pressures, the spring size required becomes excessive. Weights in combination with a lever system or with pilot units operating from the high pressure of the controlled medium, are employed. All these devices provide a degree of throttling control and are quite practical where neither an indication nor a record is required.

Mechanical-element-operated controllers are employed in intermediate ranges of pressure or vacuum from about 10,000 psi down toward absolute zero with an accuracy of about plus or minus one percent at full scale. Selection of the specific element, such as Bourdon tube or spiral, is based primarily upon the normal controlled pressure and expected variations. For example, if the normal controlled pressure is 275 psi, a spiral element would be chosen with a range of 0-300 psi, rather than 0-4000 psi.

Most elements measure the pressure above atmospheric pressure. Thus, if pressures relatively near



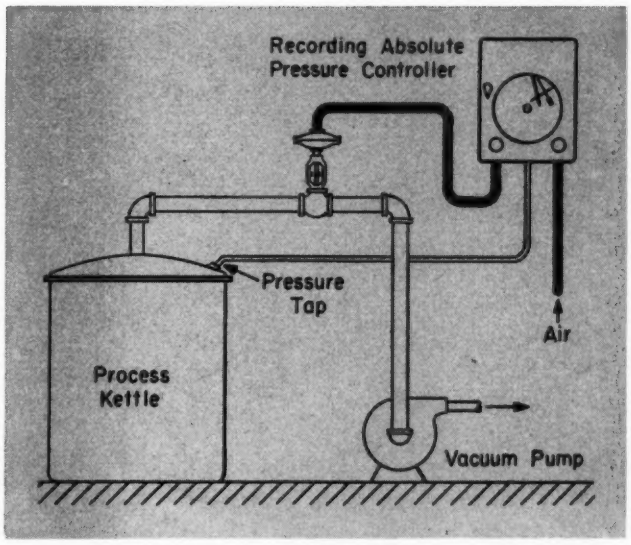
INDICATING TRANSMITTER SENDS MONITORED PRESSURE DATA TO RECORDER CONTROLLING VALVE.

atmospheric are being controlled, any changes in atmospheric pressure become a significant percentage of the measured pressure and should be compensated for automatically. The dual bellows unit provides such compensation, giving a measure of absolute pressure.

Combustion Chambers

In gas- or oil-fired furnaces and boilers, efficient combustion is promoted by control of pressure in the combustion chamber. Such pressures are usually around 0.1 in. wg, above or below atmospheric pressure depending upon the combustion system—a full-scale range of 0.2 in. wg is common. The inverted bell type of element is usually employed for such service, being sensitive to ± 0.0005 in. wg. Two inverted bells immersed in oil are mounted on the ends of a center pivoted beam. The furnace pressure is connected to the underside of one bell. A second connection to the other bell is run to the outside of the furnace near the pressure tap to compensate for changes in atmospheric pressure and ambient temperature. The inverted bell element is commonly employed as an indicator with a pneumatic control unit. A pneumatic control element positions dampers in the furnace draft duct or in the last pass of a boiler.

Electrical transducer elements cover the extremes of high pressures and high vacuums. Thermal, ionization, and barometer gages are employed for vacuum ranges from 10^{-11} up to 10 mm Hg abs. Several designs of strain gages are readily adapted for pressure measurements in ranges of 0-10,000 to 0-50,000 psi with special units for pressures up to 150,000 psi. In addition, the motion of a Bourdon tube is used in several transducer designs to provide an electrical signal for an electronic controlling instrument. Such devices lend themselves to long distance transmission of measurements and are the only available means of measurement as a basis for automatic control in the ultra-high vacuum and pressure ranges.



VACUUM IS REGULATED BY CONTROLLER WHICH OPERATES THROTTLING VALVE IN VACUUM PUMP INLET.

Control Systems

Most automatic pressure control problems are not particularly complex. Frequently, two-position control with a solenoid — or pneumatic-operated valve will suffice for close control. In applications where several capacities exist, such as in a distillation column, some transfer lag may occur. If load changes are present, the proportional-reset mode of control is selected in order to maintain the pressure at the desired value, eliminating offset.

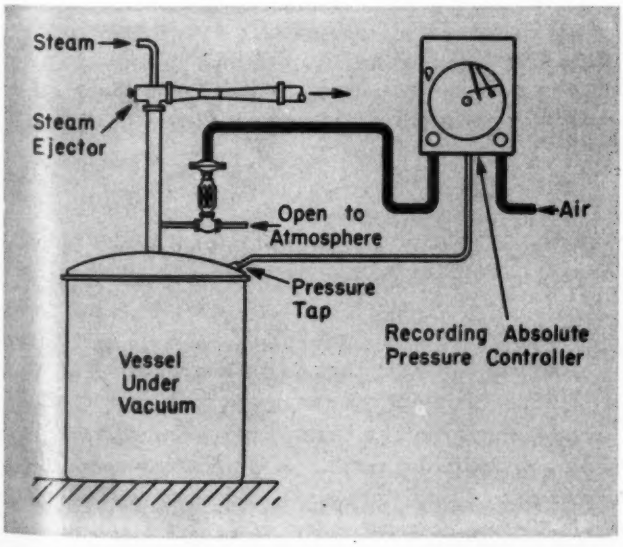
Pressure of gases and vapors such as steam can be controlled directly or indirectly in numerous ways. Common methods include:

(a) Throttling of pressure in a pipeline by means of an instrument-positioned control valve or self-operated valve (pressure reduction). The pressure being monitored is measured down-stream from the throttling valve.

(b) Control of steam or other vapor pressure by regulation of fuel input to boiler. Pressure is measured on the header and, in the case of steam, the rate of flow is often recorded on the pressure instrument chart.

(c) Venting of pressure from the vessel where pressure is built up internally because of either a reaction or the introduction of a higher pressure gas or vapor.

(d) Venting of vessels under vacuum. This is desirable where a steam ejector is used to pull a



PRESSURE CONTROLLER OPENS VALVE TO VENT TANK WHEN EJECTOR DRAWS VACUUM DOWN TOO FAR.

(Continued on page 68)

FIG. 1—SETTLING OF AN OLD COAL MINING TUNNEL CAUSED THIS DEFORMATION

The Surface and Below

WILLIAM F. SWIGER, Structural Engineer
Stone & Webster Engineering Corporation

William F. Swiger received a degree in Geological Engineering from the University of Washington in 1939 and an MS degree from Harvard University in 1940. Following graduation, he worked for Standard Oil Co. of California, E. I. du Pont de Nemours and Co., and R. V. Labarre of Los Angeles (a consultant on foundations) before joining the structural division of Stone & Webster Engineering Corp. in October 1942. Mr. Swiger now has charge of Stone & Webster's soil mechanics laboratory and directs foundation investigations for their various construction projects. He also serves as consultant on foundation studies which they conduct for other organizations.

"CAP" LABARRE, with whom I used to work, had a favorite saying (when explaining to a client the need for borings) that he couldn't see a damn bit further beneath the ground than the next fellow. He might properly have added, however, that occasionally the surface can tell a great deal about what lies beneath it. Correctly interpreted, these surface indications can serve as accurate guides for boring or test pit programs and thereby insure that the entire picture of what lies beneath the ground is obtained at minimum cost. Conditions which frequently advertise their presence are kettle holes, tunnels or old mines having roof subsidence, and sinks above cavernous limestone.

Kettle Holes

Kettle holes were formed in the outwash during retreat of the ice of the glacial periods. Occasionally large icebergs broke loose and were carried into the outwash plain. As these icebergs slowly melted, quantities of sand and gravel were piled up around them by the flow of water from under the glacier. Completion of the melting left depressions, many of which filled with water and still remain as lakes or

ponds. Others have been partially or completely filled with material eroded from the slightly higher ground around them.

Since these depressions were low and frequently wet, growth of vegetation was usually luxuriant. As silt and sand washed into the hole, roots and dead portions of this vegetation were buried. Consequently, many kettle holes are filled with a mixture of soft silts, sands, and organic matter, which is extremely compressible. The locations of these are marked only by moderate to shallow depressions. Unexpectedly encountering one while opening up a foundation excavation can be an unpleasant, and sometimes costly, experience. Since kettle holes are relics of the glacial period, they are found only in areas that were blanketed by glacial outwash deposits. There are many in a broad belt extending from southern New England, across northern New Jersey, and through to the plains states. Kettle holes are common in Ohio, Wisconsin, and Minnesota.

Mine Tunnels

Locating old mine workings can be an extremely nasty problem. While entries can be located at the surface, records and maps of the workings are frequently inaccurate or have been lost. Entering old mines is at best dangerous and usually impossible because of caving.

Mines or tunnels in hard rock which have not suffered roof collapse do not indicate their presence at the surface, and other means of investigation must be utilized. Frequently, however, the roofs of mines or tunnels in soil or in soft rock, such as shale, sag or collapse as the supporting timbers decay. The soil or rock over the tunnel settles almost vertically downward with a zone of shear deformation developing on each side located above the walls of the original tunnel. A shallow trench, having a width about equal to the tunnel, then forms at the ground surface. Fig. 1 shows an old coal mining tunnel near Pittsburgh which was exposed by strip mining operations. Deformation above the roof of the tunnel is apparent in both the shale strata and broad shallow trench at the surface.

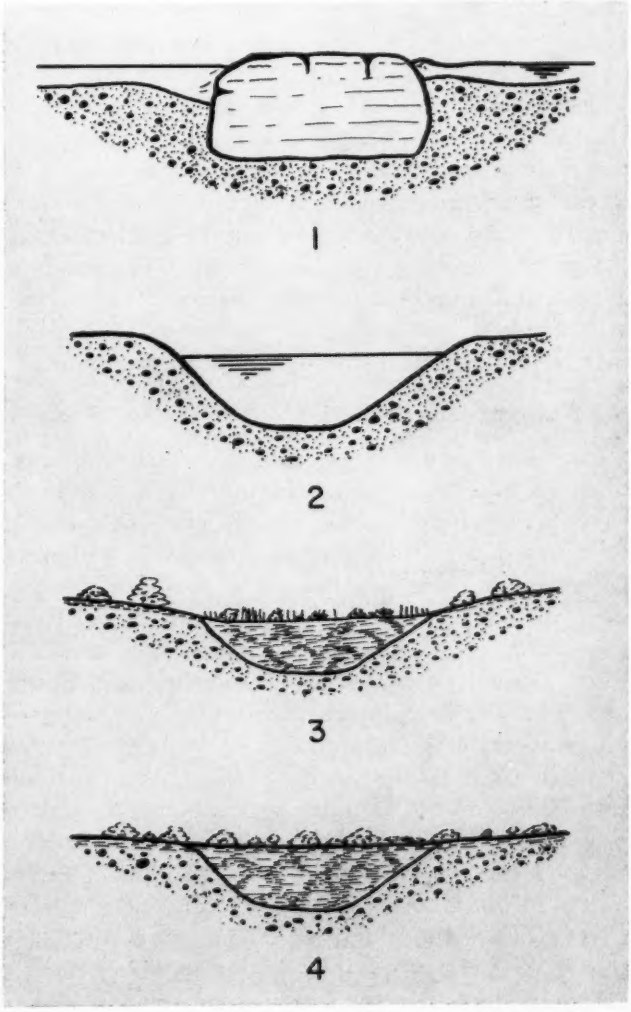
Sink Holes

Sinks develop where percolating ground waters have acted on soluble limestone formations to form channels or caverns through which material eroded from the overlying soil can be carried away. At the start, a small arched-over hole develops in the soil mantle above an opening into a cavern in the underlying limestone. This arched-over hole may be open or it may be partially filled with very soft mud. Deformation of the soil around this hole creates a very shallow, usually nearly circular depression at the ground surface.

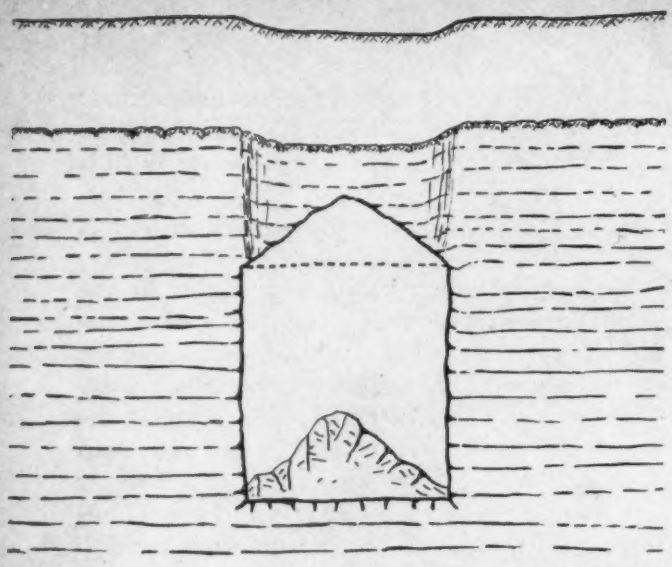
As the soil arch grows from the erosion of downward percolating waters, deformation of the soil around and above it increases. This slowly increases the shallow depression at the surface both in width and in depth. Ultimately, the hole increases to such a size that the arch is no longer able to support itself and it collapses. A typical, small sink hole is shown in Fig. 2.

Where large caverns have been eroded in the limestone, sinks may develop from collapse of the rock arch over the cavern. However, collapse of the soil arch over small channels or caverns is a more common occurrence. Sometimes this collapse occurs with spectacular suddenness. In one case, such an arch collapsed under the weight of a crawler crane burying the crane beyond any hope of recovery. In another case, collapse occurred beneath a textile mill, burying several spinning machines.

Factors which increase the probability of large open joints, caves, or caverns in the rock immediately underlying the soil mantle favor the development of sinks. These factors include: (a) conditions which favor underground drainage of surface waters, for example, generally level ground adjacent to a deeply incised river, and (b) structural features such as large joints in the rock or faults which cause



SEQUENCE IN THE FORMATION OF A KETTLE HOLE



SOIL AND ROCK OVER A TUNNEL SETTLE ALMOST VERTICALLY WHEN THE ROOF SAGS OR COLLAPSES.

cracks or previous zones where ground water flow can concentrate its cutting activity along a single path. Frequently there will be a series of sinks along and marking the course of a fault.

All of the rocks of the earth's surface have been jointed to a greater or lesser degree by crustal deformations. Most of these joint systems develop in a regular pattern in any given area and usually consist of two sets of approximately vertical joints which separate the rock into a series of prismoidal blocks. Certain of these joints are more open than the normal and these are termed master joints. Caves or caverns frequently start with and follow a master joint, and its course may be marked along the ground surface by a line of sinks. On one site in central Kentucky there was a series of eight sinks in a straight line marking the course of a small cave which had developed along a master joint.

Effect of Limestone Deposits

Pure limestone is more soluble than dolomitic or siliceous limestones and consequently channels or caverns are more easily cut in pure limestones. Presence of a pure limestone stratum immediately below the surface is a favorable condition for the development of sinks. In western and central Kentucky there is a limestone formation known as the Saint Genevieve which is extremely pure. South and west of Fort Knox, there are many square miles where this formation lies immediately beneath the soil mantle. In these areas, sinks ranging from a few feet to hundreds of feet across are so common that they often touch rim to rim.

Cavernous conditions are much less likely to develop in limestones containing beds of shale or chert (especially if the stratum is directly under the soil mantle) since these materials are insoluble. Unfortunately, sinks do not require the presence of a large cave but can develop where the drainage channel through the limestone is only a foot or two in cross section. Thus, they may be found over impure limestones or limestones which contain strata of chert or shale, usually occurring as isolated depressions. Occasionally, however, a V-shaped open joint may be eroded into the surface of the rock, and a long sink may be found above this joint. Such an elongated sink may be several hundred feet in length.

Surface Indications

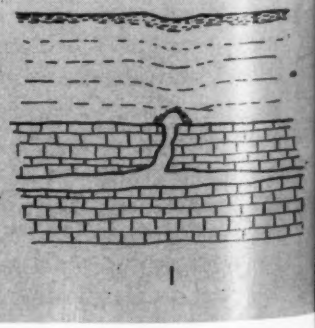
While the three conditions described are entirely different in origin and character, their surface indications (a shallow depression independent of the general drainage pattern of the area) are similar. Of the three, kettle holes may be more or less obvious, depending upon how much they have been filled by silt and organic matter. Kettle holes which are filled with water or exist as boggy areas will be detected immediately upon examining the site and can be avoided or proper precautions can be taken.

Frequently, however, kettle holes have been completely filled during the many centuries since they were formed and the surface depressions remaining are only a few inches or a foot in depth. Such shallow depressions will not be indicated on contour maps nor noted in casual examinations of the site. They can best be detected by careful examination in the slanting light of a setting sun, because then minor irregularities will be delineated by differences in light and shade.

The side slopes of the original kettle hole cannot exceed the angle of repose of the sand and gravel deposited by the stream from the glacier. This will usually be about 35 degrees and never more than 45 degrees. Thus, kettle holes cannot have a depth exceeding about one-half their width, and generally the depth will be less than one-third of the width of the hole.

Depressions above old mines or tunnels may be quite deep, but most of them are shallow and again best detected under slanting light. Man has a penchant for squaring things off and for making shafts and tunnels in straight lines. Old mine workings frequently are regular in outline and in arrangement. The depressions above such workings follow

A SINK HOLE DEVELOPS WHEN THE EROSION FROM UNDERGROUND DRAINAGE CAUSES VOIDS BENEATH THE SURFACE. SKETCHES AT RIGHT SHOW TYPICAL DEVELOPMENT STAGES.



straight lines with regular outlines. Since natural erosional depressions rarely follow a simple, regular pattern or have straight lines or edges, depressions exhibiting such patterns should be viewed with suspicion, especially in areas where it is known there have been mining operations.

A well developed sink is no problem as some of them are several hundred feet across and more than 50-ft deep. Even a Wellesley undergraduate in Geology 1 with her mind on next Saturday's dance can identify an adult sink without difficulty. However, they are much more difficult to locate while still in the infant stage. The key again is a shallow surface depression not related to the general drainage pattern of the area. These depressions usually will be nearly circular in shape but an elongated depression may be encountered occasionally. Since the paths of underground water flow determine their locations, a study of joint systems and faulting in the area will be of considerable help in locating and evaluating possible sinks at a given site.

Surface waters tend to collect in the shallow depression overlying the sink and then to drain vertically downward to the underlying channel in the rock. These downward moving waters carry with them organic matter and humic acids which discolor the soil and break down its structure to a greater depth near the center of a sink than is common in the surrounding area. This is best detected in the thickness of the "B Horizon", the zone of partially altered soil which underlies the dark colored, true top soil. This evidence of vertical flow verifies the existence of drainage channels in the underlying rock and is a useful tool in locating possible sinks. Suspected sinks should be checked by a narrow trench several feet deep crossing the center of the depression.

Value of Surface Examinations

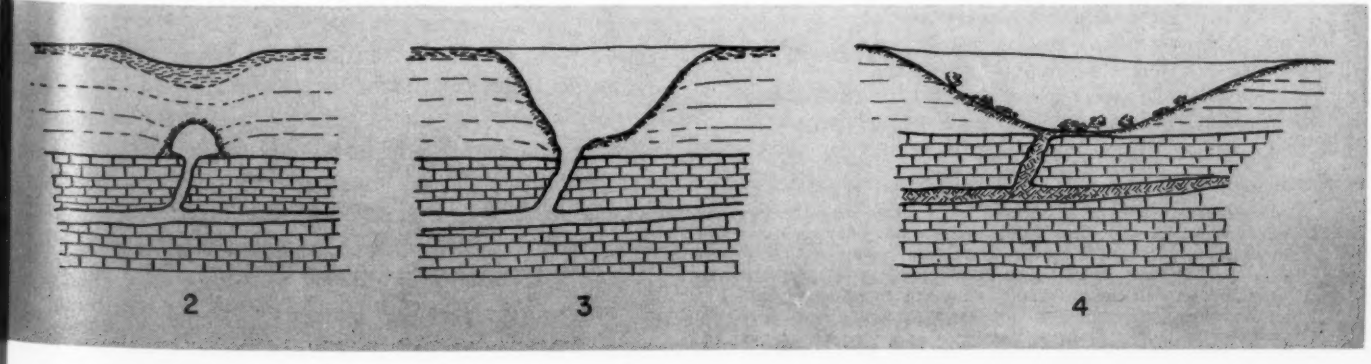
Careful surface examination of a site is a valuable and useful tool provided it is used with judgment and its limitations are recognized. A knowledge of the geology in the vicinity of a given site and of possible early mining operations is extremely useful in evaluating whether any of the conditions mentioned may be encountered. The greatest value

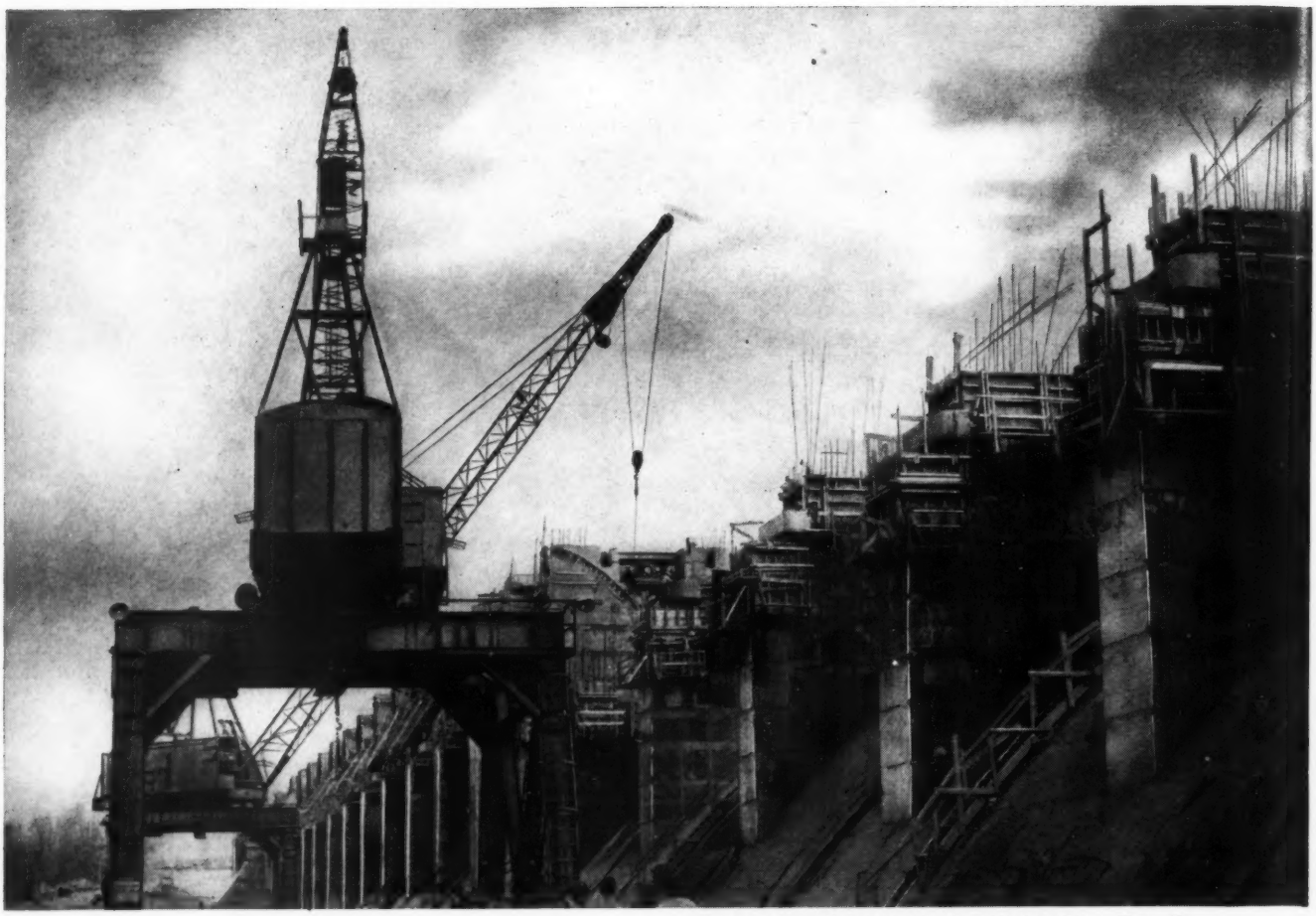
FIG. 2—PHOTO SHOWS A TYPICAL SMALL SINK HOLE

of the method is in guiding more detailed methods of investigation to insure maximum return. The greatest limitation on the method is that absence of visible surface indications does not insure absence of the conditions described.

Shallow depressions are almost impossible to detect in heavy brush, forested areas, or when the ground is covered with snow or with crops such as wheat or corn. Sometimes they have been obliterated by leveling or farming operations. Frequently the roofs of old mines or tunnels do not collapse. Then there is no surface indication and other means of investigation must be utilized.

It is, however, an extremely valuable adjunct to other methods of investigation since properly interpreted surface indications will establish where borings should be made. Careful surface examination is probably the most dependable and useful method of locating sinks. The small channels within the limestone which lead to the formation of sinks are almost impossible to locate with any reasonable number of borings. Detailed and careful examination coupled with a knowledge of the jointing system and probable faulting of the underlying rock forms a sound basis for evaluating the hazard of sinks at a specific site.





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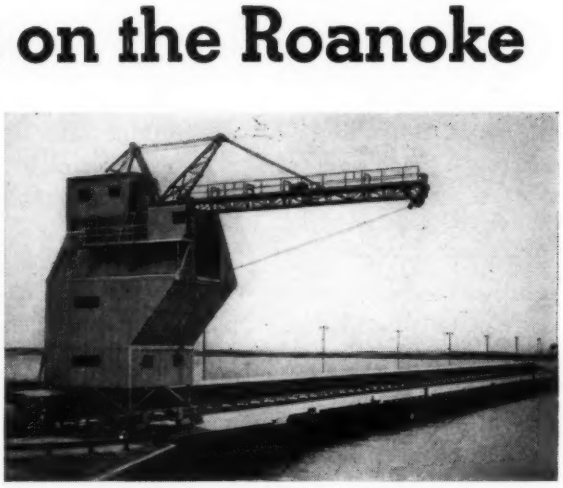

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Dr. Palyi's Page

Each month on these pages Dr. Melchior Palyi, Consulting Economist, answers readers' questions on economics and finance. Address mail to: Editor, CONSULTING ENGINEER, St. Joseph, Michigan.

- **Old Age Pension Programs Today**
- **What Will They Be Worth Tomorrow**

What accounts for the recent rapid growth of industrial pension programs?

DR PALYI: In practically all major industries there is now some form of a pension program. Since World War II (1940) the idea of pension plans has found favor with unions, management, government, and workers alike. And each for its own reasons!

During the days of wage controls, which covers almost the entire period from 1940-52, the unions found that pensions were a very convenient expedient for bypassing these controls. Management, as long as it can pass on the costs, favors pensions because they feel that it reduces personnel turnover and makes for a more stable organization. Security for the working man is always in the interests of the government. And rather than pay high taxes, many people prefer deferred wages in the form of pensions.

Are industrial pension programs sound?

DR. PALYI: The underlying idea is sound. But quite a bit of the development is unsound and in the long-range carries threatening implications. Broad coverage is not so much the danger as is the implied promise of providing pensions on an ever-increasing level. The assumption is always that business will keep booming and that companies will continue their relatively high level of earnings. And on the same note it is blandly accepted that they will continue to be able to pass on to the consumer these additional costs as they have in the past.

Although a rising industrial productivity has absorbed a part of the increased capital and labor costs of the war and post-war years, most of the cost has still been absorbed by the consumer. When the consumer will no longer be able to pay or will balk at increasing prices, that point will mark the end of the inflation period and probably the beginning of a deflation. However, any prediction as to if or when this will happen would be only a guess.

But this much can be said, many companies have assumed pension and long-term commitments which are predicated on present production capacities, sales, and rates of earnings. Some of these companies have assumed these commitments in an irresponsible fashion, others have assumed them because of labor pressure (to avoid a strike or slowdown) and some perhaps because of industry-wide bargaining to which they may be indirectly bound. Some day these pigeons will come home to roost!

To intelligently discuss the soundness of an individual pension plan, one would have to examine the specific case not only in terms of the company's financial position or earnings record, but also the type of plan, how it's financed, the investment portfolio, its actuarial basis, and other like factors.

Is the government social security system sounder than the private industrial pension programs?

DR. PALYI: The government's Old Age and Survivor's Insurance Program is financed out of the compulsory contributions of the insured. And today, practically all of the working population and their dependents fall into the insured category with plans pending in Congress to extend coverage to include those still outside the program. So far, contributions to the pension fund far exceed the obligations, and consequently the Treasury has a large surplus in income each year—at times running into the billions.

However, as time goes on, our population ages, more and more people retire, and by the end of the century it is expected that the fund will operate at a considerable deficit. This deficit, when it occurs, will be made up out of taxes.

There is little doubt that as long as the federal

government is solvent, its obligations will be met in full. As for benefits, future coverage, investment policies, and various facets of the social security system, they will be subject to the changes and revisions that future congresses and administrations decide.

More important than whether or not the government, or for that matter private corporations, will or can pay, is the question of what will the benefits be worth say 10, 20, 30 years hence.

If the dollar continues to lose purchasing power how will that affect pensions?

DR. PALYI: You realize that the dollar is now worth about half as much as it was in the 1920's. If you started your pension program in those days and the plan was a sound one, in terms of actual purchasing power, you are getting back only half of what you initially invested.

Many retired people are feeling the pinch of an inadequate monthly pension check. Through no fault of their own, they are victims of the inflation.

There are very few ways that a governmental retirement program can hedge against an inflation. A private company may arbitrarily raise the pension by adding a "cost of living" allowance, but it is not generally obligated to do so. The government, too, can vote an increase in benefits, but again that is the prerogative of the lawmakers.

Some European insurance companies offer private pension plans that promise to adjust benefits to the fluctuations in purchasing power of the currency. They do this by investing their funds in stocks or other devices that move up and down with the general market levels.

Sears-Roebuck is probably the outstanding example of a private company where the pension funds are invested in their own (Sears) stock. As long as the company continues to prosper, as it has for the last twenty or more years, the retired employees, who are in effect stockholders, feel the full impact of this prosperity in bigger and better pension-dividend checks. But Sears is the exception, hardly the rule. Few companies can point to a similar growth and earnings record, and none, including Sears, can look into the future and say where they will stand ten or even five years from now.

And what happens to pensions in periods of deflation?

DR PALYI: If the purchasing power of the dollar rises or, in other words, commodity prices are falling then your dollar is worth more and you are doing very well indeed, provided you get the dollar!

If there is a major decline in the price level it will probably be because of a decline in business activity. And along with a decline in business comes unemployment, lack of consumer buying power, a slowdown in all industrial activities.

Such a recession, depending on its depth and its length would be a heavy burden on industrial, private, and governmental pension programs. Companies which do not have fully funded plans—that is money actually set aside on an actuarial basis against the day of retirement—and most companies do not have their pension plans fully funded, will probably have great difficulty in supporting their programs. Some of them will collapse, or if the company's difficulties are only temporary, they may declare a moratorium.

The government will be doubly burdened. On the one side it loses tax revenue in periods of recession, and secondly, it is called upon to finance various relief and "pump-priming" projects. Many persons who are presently working but who are eligible for retirement, will choose to retire and draw their pensions rather than to face unemployment. The more so, since checks will look much better in times of falling prices than they do now.

So while it is true that you will get more value for your dollar in times of deflation, there is a strong possibility that you might find yourself without any pension dollar!

What is the safest type of pension—safest against inflation and against a business recession?

DR. PALYI: That's a pretty big order! Offhand, I would say the private insurance contract that makes some provisions for adjusting its benefits to the cost-of-living. However, the cost of a private annuity is probably beyond the reach of the great majority of the working people.

Again, the government social security system is as safe and as solvent as is the country itself. It depends in the last analysis upon the government's power of taxation. If tax revenue is impaired or if the deficits are too great, the entire structure of the program may have to be altered—probably at the expense of the pension recipient.

The fate of an industrial pension program hinges directly upon the fate of the company. If the company stays prosperous indefinitely; or if it is a leader or has a monopoly in its field, it may be in the position to carry out its long-term pension obligations. But companies of the latter type do not by any means characterize American industry and the former condition cannot be guaranteed.

Unemployment and layoffs, seasonal fluctuations, constantly changing products and technology, competitive markets, foreign and domestic trade policies, armament programs and political developments, are all factors that make it extremely difficult to talk with any real assurance on long-range pensions.

But if a pension plan is to have any value it must stand up for long periods. That means it must be carefully planned and financed. There may be little security and a lot of disillusionment in pension plans that fail. Unfortunately, too many of them offer expediency rather than security.

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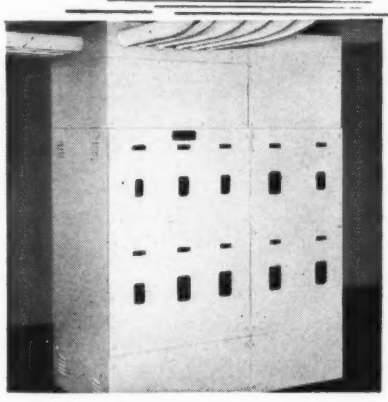


The Sinclair Oil Bldg. switchboards shown above are of dead-front construction and were fabricated to meet the engineers' specifications . . . Contractor, J. Livingston & Company; Engineers, Smith & Silverman; Builder, Turner Construction Company — all of New York City.

SINCLAIR OIL BUILDING, at 600 Fifth Ave., New York City, is one of the world's most modern office buildings . . . modern in every architectural detail . . . modern in its electrical system which is controlled by Federal Noark main service equipment, lighting and power panels, and main and sub-distribution switchboards.

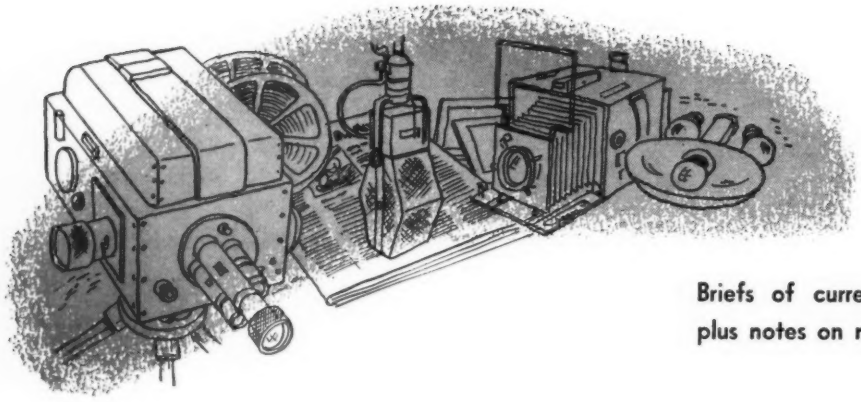
Federal Noark control equipment for electric light and power is today's top specification for new buildings and for buildings that are being modernized. Most of this equipment is assembled from standard units to meet individual requirements. All of it assures lowest installation costs . . . and is engineered for maximum efficiency, easy maintenance, and flexibility for future changes or expansion.

Whatever control problem you have — on hand or in the offing — Federal Noark is ready to give it study and come up with the solution.

Write Federal Electric Products Company, 50 Paris St., Newark 5, N. J.

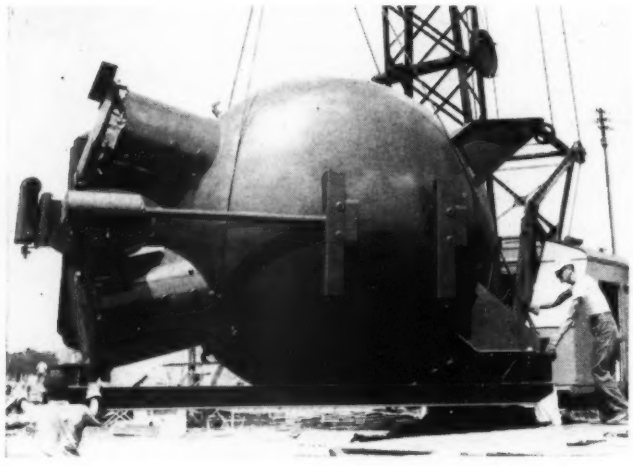
Federal Noark products: Stab-lok Circuit Breakers, Motor Controls, Safety Switches, Service Equipment, Industrial Circuit Breakers, Panelboards, Switchboards, Control Centers, Bus Duct ★ Sales offices in principal cities.

FEDERAL NOARK®



NEWS

Briefs of current interest to the consulting profession plus notes on new equipment in the field of engineering



High Capacity Circuit Breaker Designed for First 330 kv System

A massive circuit breaker for the nation's first 330 kv power transmission network has been delivered to the Beverly, Ohio, Muskingum River Plant of The Ohio Power Co., an operating company of the American Gas and Electric Co.

The unit is reported to be capable of interrupting more electrical energy in one-twentieth of a second than any breaker now in use. Interrupting capacity is rated at 15 million kva. Weighing 80 tons, it stands over 25 ft high and has three 3550 gal oil tanks measuring more than 11 ft in diameter.

General Electric is supplying a total of 16 breakers, six of which will have interrupting capacities of 15 million kva and 10 of 25 million kva. The network, now under construction, features the highest voltage in commercial operation in the United States. It eventually will link most of the major power generating stations and load centers of the AGE system, which includes seven states.

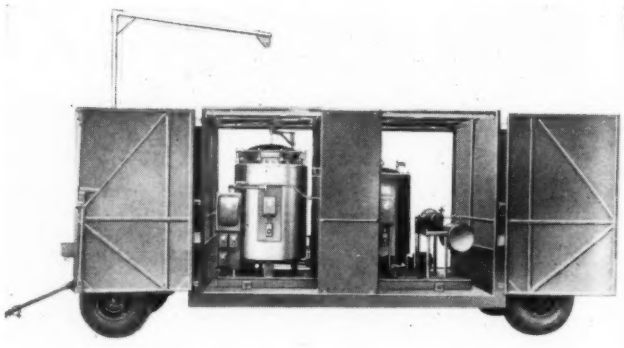
Gas Turbines Use Waste Fuel in Oil Fields

Pumping gas from an oil well back into an oil field reservoir to conserve energy and increase the field's ultimate production will soon be added to the growing list of jobs done by gas turbines. Drives of this type will be used by the Creole Petroleum Corp. in its Tia Juana Field in Lake Maracaibo, Venezuela.

Ten gas turbines will be mounted on a platform built on concrete piles about seven miles out from the shore. Gas from the flow stations will be piped to the turbine platform at a pressure of about 10 psi. Ten per cent of the gas will be used as fuel for the turbines which will operate centrifugal compressors, returning the remainder of the gas to the wells at a pressure approaching 2000 psi.

The turbines, manufactured by General Electric's Gas Turbine Dept., are two-shaft simple cycle types rated at 6000 hp each. International General Electric Co., the division which is responsible for the company's overseas operations, expects all ten units to be in operation by late July 1954.

Gas turbines were selected because they operate with less vibration and weigh only one-third as much as reciprocating engines of similar capacity.



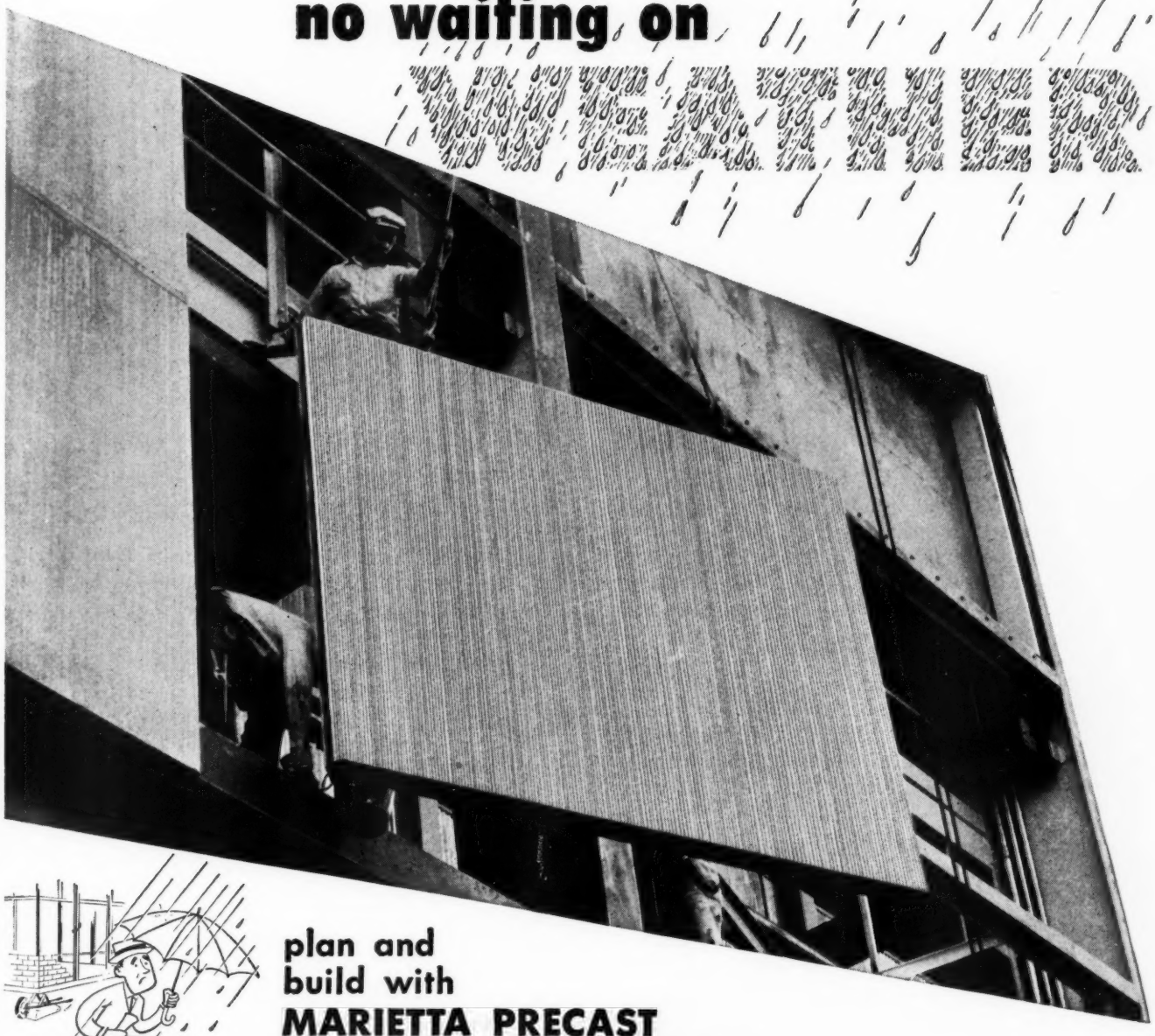
Unit Travels Power Line Routes To Recondition Transformer Oil

Dirty insulating oil in high voltage transformers and circuit breakers presents a serious problem to power companies. In recent years, progressive utilities have been transporting the dirty oil to a central filtration plant where it is restored to its original condition and then returned to the transformer.

In addition to important savings, filtration centers of this type have helped to eliminate transformer explosions resulting from short-circuits when the oil

(Continued on page 58)

no waiting on weather



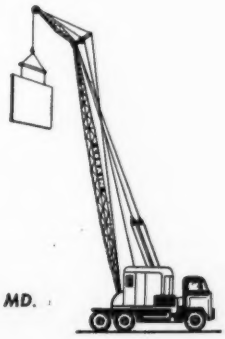
plan and build with MARIETTA PRECAST CONCRETE WALL PANELS

MARIETTA wall panels end bad-weather delays that halt conventional construction. These precast slabs let you build in every kind of weather, get your plant closed-in and in production as planned.

MARIETTA panels are cast to your specifications, trucked to your building site ready to erect. Nine men using a mobile crane can erect 3,500 sq. ft. of prefinished wall in a working day. Panels bolt directly to building framework; eliminate costly cutting, fitting, finishing on job. They can be removed, replaced, re-used to meet expansion plans. They will speed building time, cut construction costs as much as 30%.

MARIETTA insulated panels consist of two layers of reinforced concrete separated by rigid insulation. They range in thickness from 5 to 8 ins., in length from 8 to 20 ft. A 5" panel will give greater insulation value than a 12" masonry wall. A broomed finish on the exterior gives a pleasing, decorative effect. Solid panels of lightweight aggregate construction are also available.

Plan now to erect your next building on schedule, at less cost, with Marietta precast concrete wall panels. Write for literature and complete details.



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Unit Travels Power Line Routes

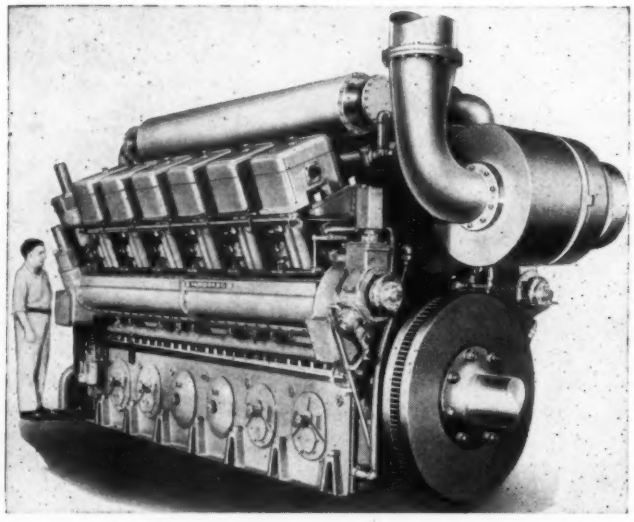
—*Starts on page 56*

becomes too impure. However, this system presents disadvantages in that the transformer must be removed from service while the oil exchange is being made, and tons of oil must be transported to and from the filtration center.

To eliminate the necessity of removing the transformer or withdrawing it from service, U. S. Hoffman Machinery Corp. has developed the Filtermobile—a complete, portable, oil reconditioning plant.

The main section of the Filtermobile consists of a large van with doors to keep out dust and weather when in transit. Platforms at both ends may be used for carrying filtering supplies and transformers. One or more transformers are usually required to reduce line voltage of current used by the filtration equipment. A hoist is provided for handling equipment and for lifting filter cartridges.

The unit is designed to be moved along rights-of-way through forests, cities, mountains, and farms. In the case of large transformers, the equipment may be left to operate overnight. The first Filtermobile is now on its way to the Montana-Dakota Utility Co. at Bismark, N. D. Two other units capable of purifying 1800 gpm of oil are under construction for Public Service Corp. of Newark, N. J. Also being built are units for the Salt River Valley Assoc., Arizona Light and Power Co., and Northern State Power Co.



V-Type Engine Features Compact Size

To meet an increasing demand for heavy duty prime movers of moderate weight and small physical dimensions, Nordberg Manufacturing Co. has developed a V-type, four-cycle engine for operation on liquid fuel, dual fuel, or spark-fired gas operation. As a diesel, the engine burns a wide range of fuel and crude oils. For dual fuel operation, it burns various types of gaseous fuels with a small percentage of pilot oil to control combustion. If gas supply is interrupted, the unit automatically changes to liquid fuel without affecting speed or load. As a gas engine, it will burn natural gas, butane, propane, manufactured gas, or sewage gas, using dual spark ignition.

An unusual feature of the unit, known as Supairthermal, is the simplicity of cylinder construction. Removable cast iron liners seat in individual cast iron jackets. This construction is said to permit directed flow of water for more efficient cooling. The entire cylinder assembly, with liner, is easily removable without disturbing cylinder liner water seals.

Units are built with 12 or 16 cylinders of 13 in. bore and 16½ in. stroke, covering a range from 2400 to 4260 hp at 450 to 600 rpm. Applications include both stationary and marine service.

International Hydraulics Convention To Be Held in Minneapolis

Meeting for the first time on the American continent, the International Association for Hydraulic Research will hold its Fifth Congress jointly with the second meeting of the Hydraulics Division of the American Society of Civil Engineers. Preparations for the convention, to be held on the campus of the University of Minnesota, are being made by local committees established by the Northwestern Section of the American Society of Civil Engineers with headquarters in the St. Anthony Falls Hydraulic Laboratory of the University of Minnesota.

Immediately preceding the convention, the Section of Hydrology of the American Geophysical Union will hold a regional meeting on the campus.

Theme of the Congress will be centered around basic relationships of sediment transportation by flowing water, density currents, air entrainment by flowing water, and waves, beach erosion, and hydromechanics of shore structures.

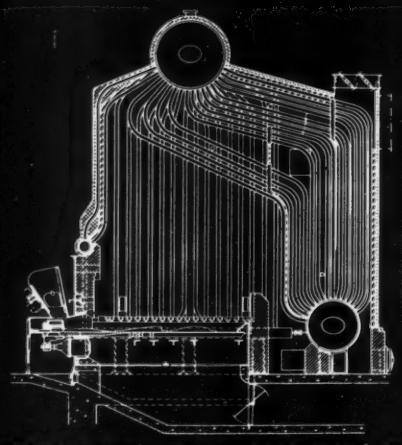
American Firm To Use Design Principles of Swiss Boiler

To continue the trend toward lower electrical power production costs in the face of rising fuel costs, designers are continually leaning towards the use of higher steam temperatures and pressures. Of particular significance at this time, because of the interest in pressures above the so-called critical pressure of 3206 psig, is an agreement between Sulzer Bros., Ltd. of Winterthur, Switzerland, and Combustion Engineering, Inc.

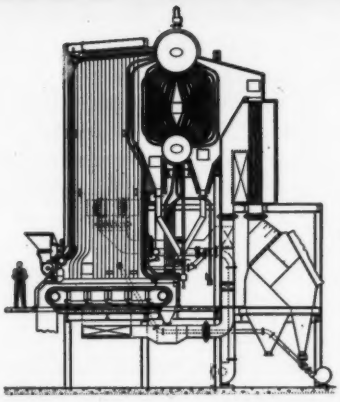
Under this agreement, Combustion Engineering will manufacture and market a once-through type boiler known as the Sulzer Monotube steam generating plant. Monotube units have long been built by Sulzer Bros., and a number of high pressure installations have been rendering satisfactory service in European countries for many years.

In order to achieve further appreciable gain in power station economy, designers feel it will be necessary to go considerably beyond the critical

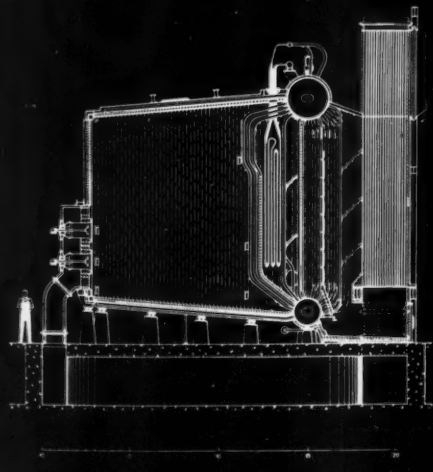
(Continued on page 60)



VU-10 Boiler — This unit is installed in a hosiery mill. It is fired by a Type E Underfeed Stoker. Capacity — 12,500 lb steam per hr; operating pressure — 100 psi; no superheat. VU-10 Boilers are available in sizes from 10,000 to 60,000 lb of steam per hr.



VU-40 Unit — One of seven, recently installed in a Chemical Plant. These boilers are fired with C-E Spreader Stokers (continuous discharge type). The capacity of each is 60,000 lb of steam per hr at an operating pressure of 325 psi. There is no superheat.



VU-50 Boiler — This unit is one of two duplicates installed in a brewery. They are fired with oil or gas. Capacity — 100,000 lb of steam per hr; operating pressure 550 psi; steam temperature 700 F. This particular design is of the bottom-supported type.

VU Utility Standards in a Standard Boiler

Electric utility companies maintain the highest equipment standards in the power generation field. Kilowatts are their business — their product... to be turned out reliably, efficiently and at the lowest possible cost. To assure this they demand — and get — the most reliable — the most efficient — the best built boilers that the market affords.

To meet their highly critical standards the utilities have long been accustomed to purchase steam generating units that were, in large measure, individually designed to meet their particular needs. And C-E Vertical-Unit Boilers, particularly in the larger sizes, are available in "custom-made" designs to suit specific requirements. In fact, VU Units have been a popular choice with utility companies for many years.

But many other designs that comprise the "VU family" are completely *standardized*...standardized without sacrifice of "custom-made" advantages. And when you standardize you reduce engineering costs, reduce manufacturing costs, reduce erection costs — in short, you save money.

Here then is a line of custom-quality boilers with all the benefits of standardization built in capacities from 10,000 lb of steam per hr up, for any pressure and temperature...and suitable for any type of fuel burning equipment.

Little wonder that industry — all industry — has found within the VU family a boiler unit exactly suited to its needs. Breweries and hosiery mills, chemical companies and steel plants — all have installed VU Boilers again and again with complete satisfaction. So can you.

B-649A

COMBUSTION ENGINEERING, INC.

Combustion Engineering Building

200 Madison Avenue, New York 16, N. Y.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT

Americans to Use Swiss Boiler Design

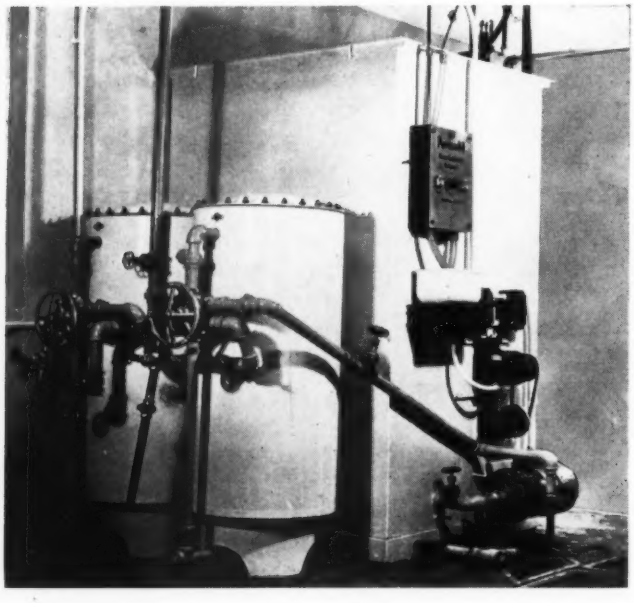
—Starts on page 58

pressure point. At pressures above this point, conversion of water to steam is instantaneous, thus skipping the intermediate bubbling phase which characterizes the transition at below critical pressures.

Although design pressures for the once-through steam generators presently used in Europe are below the critical point, the principles of the Sulzer units provide the means of building plants operable at pressures up to 10,000 psi. Combustion Engineering is presently planning the design of a 5000 psi, 1200 F unit, rated at 200,000 kw capacity. In comparison, the highest design conditions of a boiler actually in operation anywhere in the world are 2650 psi and 100 F, as found in a unit recently installed by Combustion Engineering in the Kearny, N. J. power station of Public Service Electric & Gas Co.

Design engineers expect the 5000 psi unit to have an over-all thermal efficiency of from 42 to 43 percent, as compared with the maximum thermal efficiencies of between 36 and 37 percent achieved in today's units.

The new units will be similar in appearance to today's large boilers, with tubes as high as 150 ft lining the furnace. They will be built more compactly, however, and will not require steam separating drums as required by present units. Water recycling equipment also will be simplified.



Package Water Conditioner Features Versatility

Efficiency, versatility, and simplicity are listed as important advantages of a completely integrated package water conditioning plant designed by The Permutit Co. Without alterations, the units may be used to remove turbidity, color, and organic material from water supplies, to chlorinate, to remove bad tastes and odors, to remove iron and manganese, to neutralize, to soften, and to de-alkalize.

The plant, as a complete package, forms an unusually versatile and self-contained unit with capacities ranging from 500 to 3300 gph. Each unit consists of a precipitator with a built-in clearwell, a proportioning chemical feeder control, a coagulant feeder tank, a lime or soda ash and hypochlorite feeder tank, an inlet float control valve, filter units, purifier units, and a service pump.

Among the many applications suggested are conditioning of water for small municipalities, real estate developments, lumber camps, factories, power stations, boiler plants, railroads, canneries and bottlers, breweries, laundries, and dairies.

Company Forms New Division To Unify Atomic Activities

Combustion Engineering, Inc. announces the formation of a Nuclear Power Division to bring under one expanded department the current projects concerned with the development of equipment for nuclear power generation. These include supplying of major components for an atomic-powered submarine, and conducting studies and development work having to do with practical problems of design, fabrication, and metallurgy involved in utilizing the heat generated in nuclear reactors for production of electrical power. In its various activities in the atomic field, the company is working in close cooperation with several industrial and utility groups and with governmental agencies.

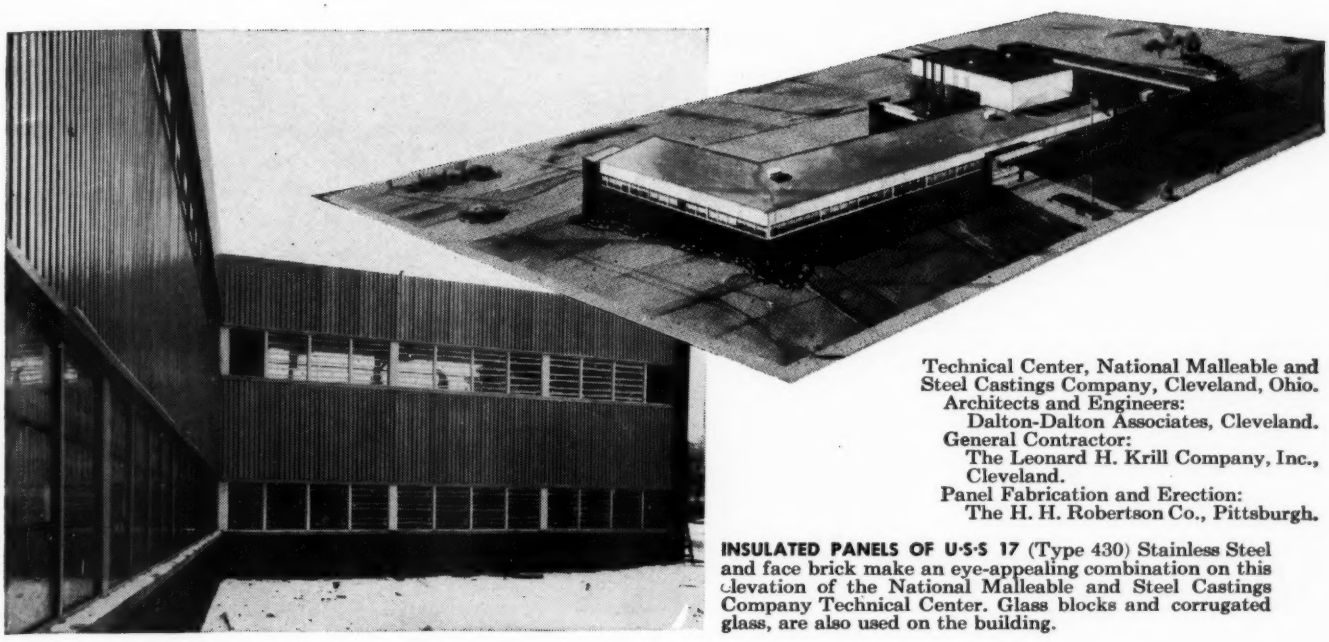
New Plant Removes Excess Volatiles from Western Coal

Designed to make Colorado coal grow several million years older in a matter of seconds, a new pilot plant for the test production of char has been completed at the Pueblo Steel Mill of The Colorado Fuel and Iron Corp. The new Petit char plant is the second of its kind in the world.

Colorado coal is believed to be about 80 million years younger than eastern coal, and is therefore more volatile. The new plant is actually a low-temperature furnace which removes part of the excess volatile matter to produce a low-volatile char for blending with coals. Mixing the resultant char with Colorado coking coal improves the quality of the coke which is later used in steel making.

Begun in January of this year, the plant was constructed by CFI engineers working with the Koppers Construction Co., according to the plans of the Societe de Technique Industrielle of Paris, France, headed by M. Daniel Petit, designer of the plant.

The true value of this method of improving western coal is expected to be established over a period of time. Test charges in coke ovens and blast furnaces are expected to provide definite and final proof of the value of char blending.



Technical Center, National Malleable and Steel Castings Company, Cleveland, Ohio.
Architects and Engineers:
Dalton-Dalton Associates, Cleveland.
General Contractor:
The Leonard H. Krill Company, Inc., Cleveland.
Panel Fabrication and Erection:
The H. H. Robertson Co., Pittsburgh.

INSULATED PANELS OF U·S·S 17 (Type 430) Stainless Steel and face brick make an eye-appealing combination on this elevation of the National Malleable and Steel Castings Company Technical Center. Glass blocks and corrugated glass, are also used on the building.

New Technical Center takes advantage of insulated panels of U·S·S 17 Stainless Steel

IF you're looking for striking beauty that time and weather won't affect, insulated panels of U·S·S 17 (Type 430) Stainless Steel are the logical choice for your new building, no matter what its function may be.

For example, National Malleable and Steel Castings Company, Cleveland, Ohio, constructed its new office and laboratory building with Stainless Steel panels used in combination with face brick, glass block and heat-absorbing corrugated glass.

Approximately 9,000 square feet of the wall surface of the new National Technical Center is Stainless Steel. In addition to their striking appearance, these panels will yield many other benefits, both during erection and after occupancy.

Since the structure is completely air-conditioned, the low coefficient of thermal transmission ("U" factor) of these insulated panels is extremely important. Erection took place in midwinter, without regard to weather conditions. Initial cost is well in line with comparable materials and its low maintenance cost will save money throughout the long life of the building.

For full information on this modern material of construction, send for our new book containing the latest data on construction with panels of U·S·S 17 Stainless Steel.

United States Steel Corporation
525 William Penn Place, Room 2815-F
Pittsburgh 30, Pa.

☐ Please send me your new booklet on U·S·S 17 Stainless Steel for industrial buildings.
☐ Please arrange to have fabricators of Stainless Steel wall panels send me literature on their particular type of construction.

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United States Steel produces only the Stainless Steel sheet and strip from which panels of this type are made; the panels themselves are fabricated by a number of our customers.

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U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

USS

3-805-A

UNITED STATES STEEL

—Starts on page 22

air input averaged 2407 cfm and the gas output 2743 cfm. In this period, 83 million cu ft of gas were produced having the following average analysis:

Analysis, percent	
Carbon dioxide	9.7
Illuminants	0.3
Oxygen	0.5
Hydrogen	9.2
Carbon monoxide	13.1
Methane	1.5
Nitrogen	65.7
Heating value, Btu per cu ft	93

When a comparison was made with the results of the January to May 1952 operation, encouraging progress toward improved quality of products, rate of gas production, quantity of coal gasified, and elimination of system leakage was noted. This operation also represents the first instance in which units were installed and operated as planned.

Progress also has been made in developing satisfactory underground gasification units and in solving various problems. In all of the experimentation to May 1952, leakage of gas-making fluids and product gases from the systems was serious, averaging 48 percent of the input air pumped underground during the January to May 1952 period. From August to November 1952, the gross leakage of the dual system averaged less than 14 percent, and during the period of peak operation 5 percent. This improvement was accomplished by better choice of inlet locations (the point of maximum input pressure) and by more satisfactory inlet installations. The problem is not solved, but definite advances have been made.

When operating a unit system, the coal utilization will be affected by the quantities of unreacted coke remaining underground. Coal will be gasified over a portion of the site area. In other sections, especially at the final perimeter, coal will be carbonized only with the choice of operating conditions determining the quantity of unreacted coke. Operations concluded in November show considerable improvement over those of the January to May period, indicating that proper location of multiple units within a grid system may aid recovery of coked perimeters.

System resistance to the flow of gas-making fluids affects the pumping costs and consequently, the cost of the finished product. During the August to September operation, the input pressure averaged 30 psig for the entire period and 27 psig during the period of peak operation. The ratio of the energy present as the heat of combustion of the product gases to the theoretical adiabatic energy required for air compression for the entire period is 24 to 1. For the period of peak operation it is 31 to 1, but if the pressure drop were reduced from 27 to 10 psig, the value of this ratio would change from 31 to 1 to about 67 to 1.

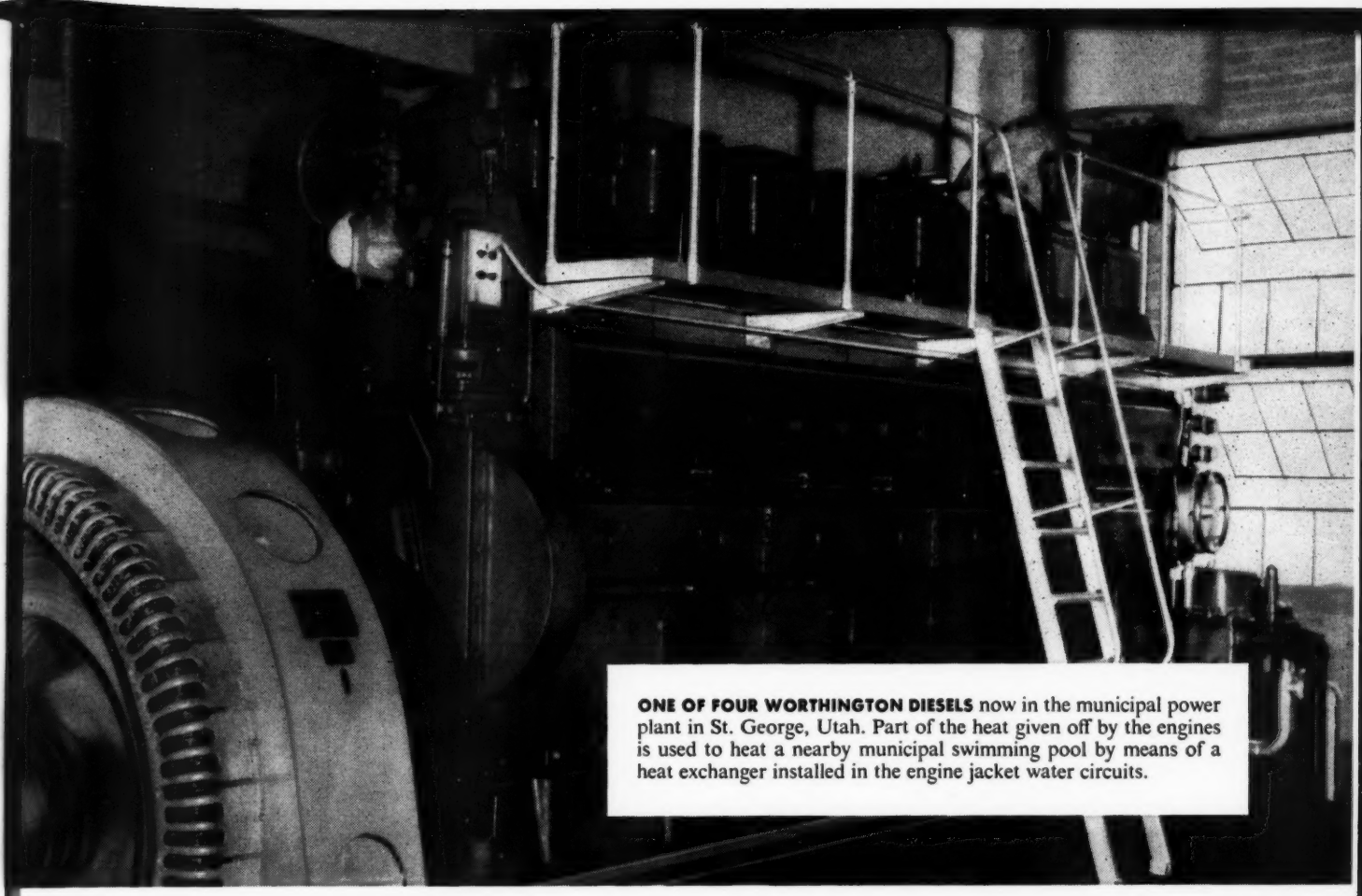
In each of these instances, the energy present as heat of combustion of the product gases is far greater than the theoretical energy for compression. However, in practical application the inefficiencies both in utilization of the heat of combustion and also in air compression will greatly reduce these values. Thus, every effort should be directed toward decreasing the pressure required to force the gas-making fluids through the underground passages and increasing the quality of the product gases, thereby increasing the ratio values and decreasing the system operating costs. Solutions to this problem will be found in improved methods of site preparation such as better application and modification of electrolinking-carbonization and improvements in borehole design.

In November, trials were conducted in the southern section of the system using oxygen in place of air. Steam was not added to the oxygen since excess water was already present in the underground system. Tests were made using oxygen input rates of 450, 600, and 800 cfm for 22, 36, and 12 hours respectively. There was little difference in the results obtained using either 450 or 600 cfm oxygen input rates, and the product gas volume was 2.25 times the input for each trial. An average analysis for the two periods and the composition of the best quality gas produced are as follows:

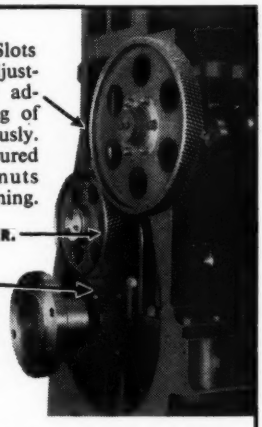
Analysis, percent	Average	Best
Carbon dioxide	48.4	40.1
Illuminants	0.3	0.2
Oxygen	0.2	0.2
Hydrogen	24.3	27.0
Carbon monoxide	20.4	26.6
Methane	4.4	4.9
Nitrogen	2.0	1.0
Heating value, Btu per cu ft	195	227

Results of the oxygen test using an 800 cfm input rate were inferior to those obtained during the preceding trials. The relative volume and heating value of the product gas decreased, as did the hydrogen, carbon monoxide, and methane contents. The proportion of carbon dioxide present increased. It is not known why the quality of the product was inferior at the higher rate. Possibly either the rate of oxygen input was too high for the size of the system, or the duration of the test was insufficient to give stabilized operating conditions. A more likely possibility is that moisture inflow into the reaction zone increased at this time, which resulted in a decreased level of operation. Measurements during this stage indicated an increase of approximately 25 percent in the moisture content of the effluent gases.

During the entire course of the oxygen gasification



ONE OF FOUR WORTHINGTON DIESELS now in the municipal power plant in St. George, Utah. Part of the heat given off by the engines is used to heat a nearby municipal swimming pool by means of a heat exchanger installed in the engine jacket water circuits.



MAIN CAMSHAFT GEAR. Slots in gear provide single adjustment for retarding or advancing injection timing of all cylinders simultaneously. Final gear adjustment secured with castellated locknuts wired after final tightening.

FREE FLOATING IDLER GEAR.

SPLIT GEAR KEYED ON CRANKSHAFT. Permanent adjustment for perfect alignment with idler gear is easily accomplished.

WORTHINGTON HELICAL STEEL GEAR TRAIN
used on these Worthington dual fuel engines . . .

1. Provides accurate and positive control of engine timing.
2. Is located at flywheel end of engine for smooth gear operation as power impulses are absorbed by the flywheel.
3. Uses controlled automatic oil jet lubrication that eliminates wear.
4. Assures correct engine timing . . . keeps engine running smoothly . . . results in low fuel consumption and minimum engine maintenance.

Good planning keeps municipal power plant profitable

Eleven years ago, the City of St. George, Utah, started power-plant operations with two Worthington four-cycle, direct injection Diesel engines. Today, the capacity of St. George's plant is 500% greater than it was in 1942—and profits are still being returned to the City of St. George.

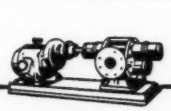
St. George planned its power plant to keep pace with increasing power needs and to continue to show profits. That's where Worthington came in. Worthington engineers helped St. George select exactly the right size and type of equipment—engines, circulating water pumps, fuel transfer pumps and air starting equipment.

Because of its complete satisfaction with the original Worthington units, St. George purchased a third Worthington Diesel in 1947, a fourth in 1949, and a fifth in 1950. At present a total of four units are in operation, one unit having been replaced by a larger unit in 1950.

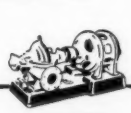
Worthington may be able to help save power costs for your community, too. Write your nearest Worthington district office or Worthington Corporation, Engine Division, Section E.3.2, Buffalo, New York. E.3.2

Worthington-Built Auxiliaries

ENGINE STARTING COMPRESSORS



OIL TRANSFER PUMPS,



COOLING WATER CIRCULATING PUMPS

EVAPORATIVE-TYPE ENGINE WATER COOLERS

Economical Continuous Power—Diesels, Oil and Dual Fuel, and Spark-Ignition Gas Engines, from 190 to 2,100 bhp.

WORTHINGTON
Engines

TABLE 1—AVERAGE OPERATING DATA USING AIR BLAST FOLLOWED BY STEAM RUN

	Group 1		Group 2	
	Air blast	*Steam run*	*Air blast*	*Steam run*
Average length of cycle, hours	19.8	4.34	17.75	4.04
Input air rate, cfm*	1215		1288	
Input steam rate, lb per hr		1174		2113
Dry gas produced, cfm*	1808	582	1779	586
Moisture in product gas, moles H_2O per mole dry gas	0.20	0.60	0.17	0.51
Analysis of product gas, percent				
Carbon dioxide	13.2	21.9	12.0	20.5
Illuminants	0.2	0.5	0.4	0.3
Oxygen	0.2	0.3	0.5	0.3
Hydrogen	14.3	52.5	12.5	54.5
Carbon monoxide	10.2	10.9	10.6	13.2
Methane	3.5	9.2	2.1	7.0
Nitrogen	58.4	4.7	61.9	4.2
Heating value, Btu per cu ft*	119	308	104	297
Specific gravity	0.90	0.57	0.92	0.57

*Values are at 60 F, 30 in. Hg, dry basis.

tests, both the quantity of moisture accompanying the product gases and the material balance calculations indicated the presence of high concentrations of moisture in the reaction zone. This moisture decreased the quality of the products obtained and accounts for the high oxygen consumption. However, these tests constituted the first experiments using oxygen in quantities large enough to obtain reasonably stable operating conditions. Results indicate satisfactory synthesis gas can be produced by underground gasification, providing improved control of the operating variables can be achieved.

Experimental trials using oxygen were completed on November 12. Operation of the southern system then was continued until December 20, using various combinations of alternate air blast and steam runs, each of several hours duration and in the same direction. Immediately after the oxygen experimentation two groups of these cycles were made, and the data obtained are summarized in Table 1.

Analysis of Oxygen Tests

It is noted that the air blast gases in each group of cycles had approximately the same composition, with the heating values in Btu per cu ft averaging 119 for the first group and 104 for the second group. Analyses of the gases produced during the steam runs also were similar, as indicated by the respective heating values of 308 and 297 Btu per cu ft. The major difference between the two groups of cycles is in the double rate of steam input during the second group. Since the rate of gas production as well as the quality remained practically constant, the importance of natural moisture entering the underground reaction zone is again apparent. It appears probable that a fraction of the steam admitted condensed before it reached the reaction zone, and in either case the steam input rate was greater than existing conditions required.

Following these two groups of cycles, experimentation was continued using various time cycles, including balanced cycles consisting of 6-hour air blast operation followed by a 6-hour steam run. By this time the quantity of coal utilized relative to the size of the unit was large, and deterioration in product quality was occurring. However, during the steam runs it was possible to produce water gas having a heating value ranging from 220 to 300 Btu per cu ft. Results of these experiments, while somewhat qualitative, indicate that synthesis gas can be produced in this manner.

It appears likely that underground gasification of coal can be employed to produce specific gases for various commercial usages provided certain limitations are recognized and improved methods of control are developed. Progress has been made toward more effective control of the process.

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1. Dowd, James J., Elder, James L., Capp, J. P., and Cohen, Paul, *Experiments in Underground Gasification of Coal, Gorgas, Alabama;* Bureau of Mines Report of Investigations 4164, 1947.
Elder, James L., Fies, Milton H., Graham, Hugh G., Montgomery, R. C., Schmidt, L. D., and Wilkins, E. T., *The Second Underground Gasification Experiment at Gorgas, Alabama;* Bureau of Mines Report of Investigations 4808, 1951.
Fies, Milton H., *A Review of the Experiments Throughout the World in the Underground Gasification of Coal.* Presented before the American Institute of Mining and Metallurgical Engineers, New York, New York., Feb. 1952.
2. Forrester, J. D. and Sarapuu, Erich, *Process of Underground Electrocarbonization,* University of Missouri, School of Mines and Metallurgy, Bulletin 78, 1952.

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BUILT TO MEET MODERN INDUSTRIAL REQUIREMENTS

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Horizontal Type

Ceiling suspension type with heavy duty welded steel fin-and-tube heating element. The rugged arc-welded construction outperforms and outlasts heating elements made of thinner non-ferrous metals. Avoids their expansion-contraction faults, yet has the same BTU efficiency. Ten basic sizes with capacities from 30 Mbh to 490 Mbh. Totally enclosed motors. (Extra heavy non-ferrous coils also available.)

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nyb

MEN IN ENGINEERING

★ W. H. Wheeler, consulting civil, mechanical, and mining engineer of Minneapolis, has been elected president of the Minnesota Association of Consulting Engineers. He succeeds T. E. Roche, consulting electrical engineer. Roche will continue as an ex-officio member of the executive board of the Association for the ensuing year. Other newly elected officers include: vice president, M. A. Johnston, consulting structural engineer; secretary-treasurer, H. G. Sierk, head of the Mechanical Dept. of Magney, Tusler and Setter. Also elected to the executive board are the following: H. M. Bird, consulting mechanical engineer of Osseo, Minn.; G. Moore, consulting electrical engineer of the firm of Gausman & Moore of St. Paul, Minn.; J. Salo, consulting civil engineer of Duluth, Minn.; and A. L. Sanford, consulting mechanical engineer of the firm of C. H. Johnston, St. Paul, Minn.

★ E. A. Charlton, associated as an executive and consultant with the paper industry for 35 years, joins the H. K. Ferguson Co. serving in an executive capacity.

★ F. H. Bulot is named president of the newly formed firm of Francis H. Bulot, Consulting Engineer, Inc. Offices are located at 411 West Fifth Street, Los Angeles; 1041 East Green St., Pasadena and 116 East Broadway, Costa Mesa. Other officers elected are: R. G. Bulot, vice president, and Lucille O. Harper, secretary-treasurer. Also associated with the new company are J. T. Robinson, C. W. Messing, K. Brunner, C. C. Plummer and Jane Spellman.

★ J. K. Sands joins McKinsey & Co., management consultants. Sands just completed a two-year tour of duty with the U. S. Navy in Korea.

★ J. P. O'Donnell, consulting chemical engineer of James P. O'Donnell, Engineer, New York City, recently opened a branch office at Beaumont, Tex., with C. A. Knight, former chief engineer of Magnolia Petroleum Co. Refinery, in charge.

★ P. E. Landolt, consulting chemical engineer, New York City, is elected president of the Columbia University Engineering Alumni Association for 1953-54.

★ After joining Grothe & Swanker, Inc., Cleveland consulting engineers and designers, early this year as manager of sales, L. A. Sacha, Jr., is now a vice president and director of the firm. Formerly, Sacha was with Designers for Industry, Inc.

SACHA CORDELL

★ J. E. Cordell, formerly associated with Ebasco Services, Inc. as project coordinator, is appointed assistant sales manager for the Electrical Div., Southern States Equipment Corp., Hampton, Ga. A tour of duty in the U. S. Navy was sandwiched between his new position and his former association with Ebasco.

★ J. N. H. Christman, consultant retired from Standard Oil Co. of Ohio, is now chairman of the Consultant Engineers Division of the Cleveland Engineering Society. His division officers include: vice chairman, James J. LaSalvia, chief engineer, Osborn Engineering Co.; recorder, Levi B. Mumma, consulting engineer; member-at-large, Dr. Antonio Longoria, consulting engineer.

★ A. W. Krickl is appointed assistant to the president, Catalytic Construction Co. Krickl comes to Catalytic from Stone & Webster Engineering Corp.

☆ M. M. Polson, mechanical engineer from England, joins the staff of Sam Tour & Co., Inc. He will be active in plant layout and production planning, design and development work, and supervising the testing of materials and equipment. D. A. Lawless, formerly with Kaiser Aluminum and Chemical Corp., is named to the metallurgical dept. as assistant director.

★ L. McDonald, (right) partner of McDonald Brothers, Los Angeles, announces the addition of a design and engineering department which will be an integral part of their present construction service. R. D. Koons, (center) formerly with the Bechtel organization, heads the new addition. G. S. Ballew, (left) formerly with Stone & Webster Engineering Corp., will manage McDonald's service departments for the petroleum industry.

★ Prof. A. H. Burr of Cornell will spend a sabbatic leave next academic year in Brazil at the Institute of Aeronautics in the Brazilian government's Aeronautics Center, Sao Jose dos Campos, Sao Paulo. (CE, July '53, p. 38)

★ D. I. Bohn, chief electrical engineer for Aluminum Company of America, now heads up the special electrical development engineering work. L. N. Grier, assistant chief electrical engineer, succeeds Bohn as chief electrical engineer.

★ Appointment of G. M. Quarnstrom as director of public relations for the Service Bureau, American Wood-Preservers' Association is announced. Service Bureau engineers are available for consultation as follows: W. D. Keeney, Chicago; R. H. Mann, New York City; R. L. Osborne, Washington, D. C.; W. A. Stacey, Lawrence, Kans.; W. R. Bond, Portland, Ore.; and Ben S. Sawyer, Jr., Sacramento, Calif.

★ The Stanley Engineering Co. opened Chicago offices in Rm. 409-10, the Utilities Bldg., 327 La-Salle St., August 1. The main office continues to be located in Muscatine, Iowa. F. W. Edwards is in charge of the new office. Since 1948, he has been director of civil engineering at the Illinois Institute of Technology. On temporary leave, he was general manager of the Centennial of Engineering held in Chicago last year.

EDWARDS

★ Dr. Karl B. McEachron, General Electric scientist and well-known authority on lightning, was recently elected an honorary member of the Societe Francaise des Electricians. Only a select few living Americans are honorary members of this French Engineering Society.

★ H. J. Barten and Dr. E. F. Lype are promoted to senior engineers in the propulsion and structural research department at Armour Research Foundation and are available as consultants on a variety of projects in their fields.

★ Headquarters of the Freyn Dept., Engineering and Construction Div. of Koppers Company, Inc. moved from Chicago to Pittsburgh, August 1. Dr. W. H. Mathesius, Freyn consultant, continues to have his offices at 109 N. Wabash in Chicago, along with several members of the sales force and the entire Engineering Department.

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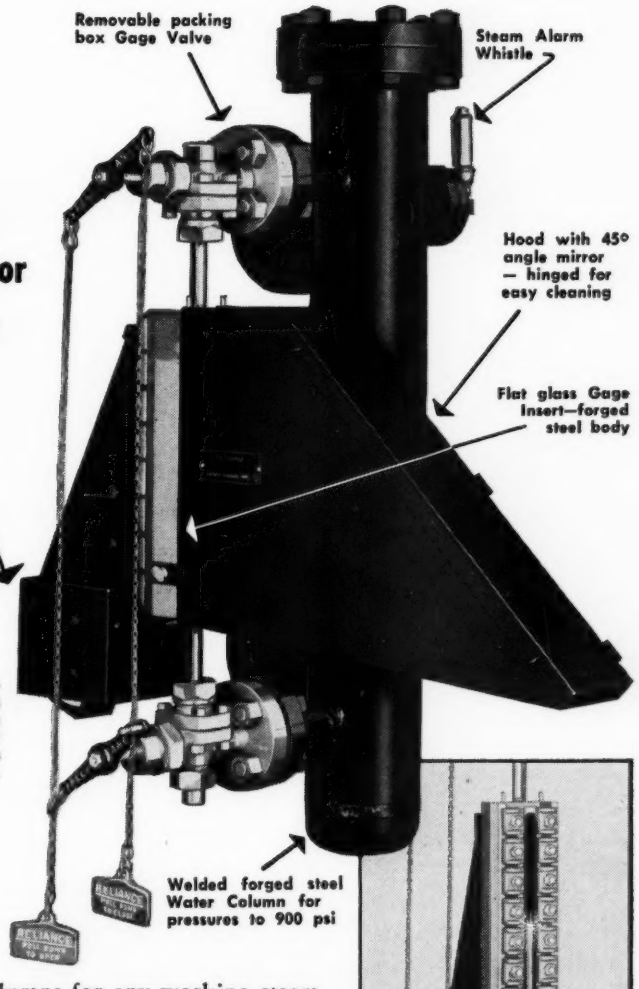
Mercury Lamp Gage Illuminator for extra-clear and distant reading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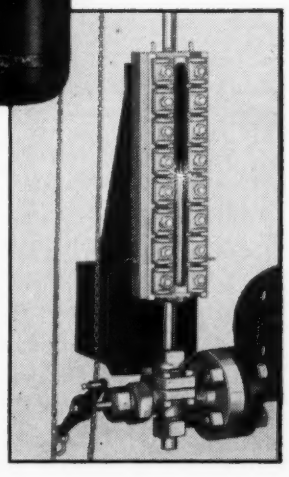
Recommended for conditions where gages are 40 ft. or more from operating level, or for extra bright meniscus image. See cut at right.



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BOILER SAFETY DEVICES

Pressure Control

—Starts on page 45

vacuum because the ejector normally will not operate over a very wide range of steam flow. Using the venting method, steam flow to the ejector can be set at its optimum value.

(e) Positioning of a valve in the suction line, when centrifugal pumps are used to draw a vacuum.

(f) Cutting a compressor on or off which is supplying the high pressure medium to a vessel.

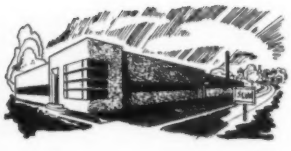
(g) Regulation of cooling water flow to the condenser for column pressure control in distillation processes where overhead vapors are condensed. Alternately, simpler control is sometimes obtained by release of non-condensable gases from the vessel receiving the condensed overhead product.

Remote Transmission

As with other variables such as temperature or flow, pneumatic transmission of pressure measurements to an indicator or recorder on a centralized control board is often desirable to completely isolate all process piping containing high pressure or hazardous fluids from the control room. The pressure measuring instrument can be a simple indicator with the control unit incorporated in the panel-mounted recording instrument. Alternately, control can be included in the indicating transmitter, minimizing lag in the air line to the valve.

Recent trends in panel board instruments have indicated increased interest in miniature recorders, about 5 in. square. These are often incorporated in a schematic diagram on the panel board in a way which graphically shows the operator the physical location of the recorded process pressure. Such recorders operate from air signals piped from pneumatic transmitters. Panel board space is conserved and operator training time is reduced markedly.

Non-indicating controllers of the pneumatic-balance type can operate in such systems from the same air signal piped to the miniature recorder. Such controllers, often called "stack controllers" because of their construction from a group of discs, can be connected in the transmitted air line at any point—either near the process for minimum lag or at the panel board where they are more conveniently adjusted and serviced.



New Legislation

—Starts on page 34

unfavorable to the development of industry, and to propose a sound program of industrial promotion including whatever reorganization is necessary to give the state a wholesome development. Belief has been expressed that the study might lead to creation of a new State Department of Commerce.

A bill enacted in Oregon created a new State Development Commission, with a $50,000 appropriation for the 1953-55 biennium, for the purpose of attracting new industries and payrolls. Minnesota lawmakers expect similar results from legislation providing for a new state development council to act in an advisory capacity to the State Department of Business Research and to the governor.

Florida's Governor McCarty created, by proclamation, a new 17-member Council for Industry and Commerce to foster industrial and commercial development. The State Advertising Commission was designated by the governor as the official state agency to cooperate with the council.

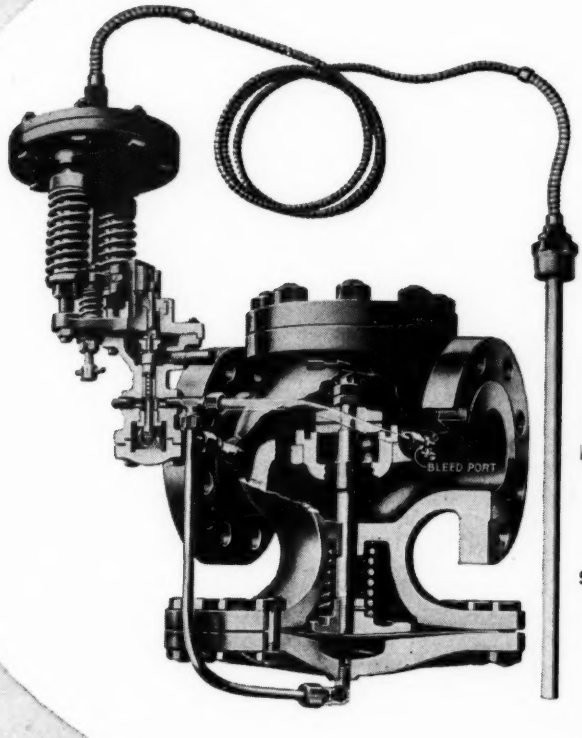
Other legislative action of interest this year included approval by the Oklahoma legislature of a proposed state constitutional amendment to liberalize a restriction which now prohibits corporations from holding land outside city limits for more than seven years unless the land is in connection with their business operations. Advocates of the amendment, which will be submitted to the electorate in 1954, said it will permit insurance companies and others to invest in plants which they can lease to industries wanting to locate in the state.

Tax Concessions

Looked upon less favorably by lawmakers were proposals to foster industrial development by means of new or broadened tax concessions. Rejected in Maine was a proposed constitutional amendment which would have provided a legal basis for tax concessions to industries by permitting the legislature to establish different classifications of property for taxation at varying percentages of their value. Although the constitution now provides that taxes shall be apportioned equally, a proponent of the proposed change said it has "long been the proven policy of this state to tax industry on a much lower value than other property."

Unsuccessfully introduced in the Massachusetts legislature was a bill to give new industries freedom from taxation for five years. A bill to encourage new industry by providing tax exemptions failed to be enacted in Oklahoma, and a similar bill aimed at promoting the development of certain mining and related industries, was killed in Wyoming.

3 Reasons for Accurate Regulation



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SENSITIVE PILOT

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Packless construction eliminates the need for closely fitted parts that may stick or bind due to dirt or uneven expansion of the parts.

In Spence Temperature Regulators, the Main Valve is actuated by a large balanced metal diaphragm which responds to the slightest changes in temperature.

Sensitive Pilots are designed to limit heater pressure to an adjustable maximum. As the temperature at the thermostat drops a few degrees there is a corresponding increase in steam pressure up to the limit for which the Pilot is set.

With regulators that respond only to temperature, an increase in load is accompanied by a momentary decrease in steam pressure caused by faster condensation in the heating element. There is a time lag until the thermostat senses the temperature drop and opens the valve wider. Spence Temperature Regulators act like pilot operated pressure regulators when this occurs. They respond instantly to maintain the steam pressure until the thermostat has a chance to further increase it as needed for the heavier load.

These plus other design features explain why Spence Temperature Regulators function dependably and accurately year after year, without requiring extensive repairs or special attention.

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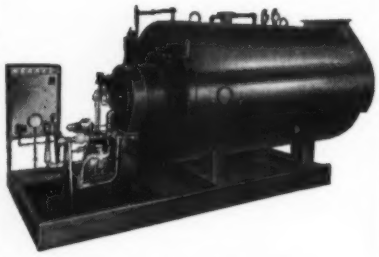
SE128

SPENCE ENGINEERING COMPANY, INC., Walden, New York



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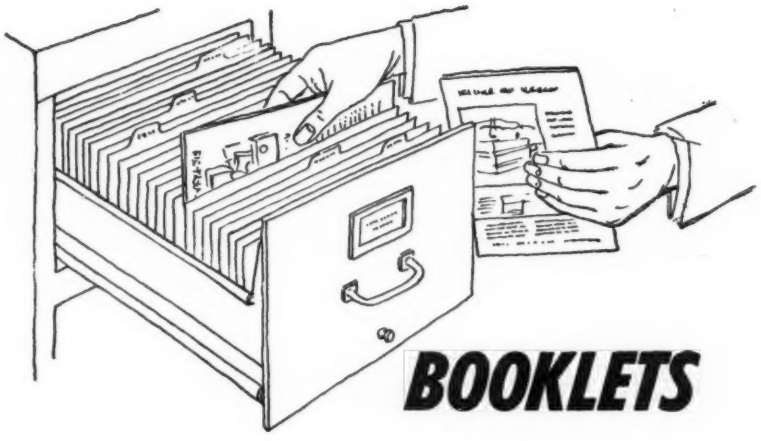


BOOKLETS

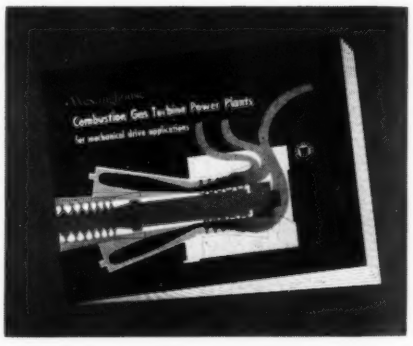
COOLING PROBLEMS—Pre-fabricated and custom-engineered apparatus for solving residential, business, and industrial cooling problems are diagramed and described in 15-page brochure G-53. Two useful charts list the type of equipment recommended for varied jobs and industries as well as dry bulb and wet bulb temperature data. *Degree° Corp., 2301 Sabine, Houston, Texas*

AUTOMATIC CONTROLS—"A Proposal for Managements with Vision" is the title of a 6-page pamphlet describing a specialized engineering service for making plant operations automatic. This service consists of field consultation, analysis, design, and construction, as well as start-up and indoctrination of new operators. *CDC Control Services, Inc., 400 S. Warminster Rd., Hatboro, Pa.*

METAL WALL PANELS, incorporating fibrous glass insulation, are appraised in 8-page bulletin IPC-53. In addition to describing how panels provide economical curtain wall construction, the booklet pictures a variety of colors and textures that can be used to compliment architectural designs. Specifications list interior as well as exterior types. Engineering drawings present construction details. *The Steelcraft Manufacturing Co., 9017 Blue Ash Rd., Rossmoyne, Ohio*

STATIONARY VACUUM CLEANING SYSTEMS are described in 8-page bulletin 121 B. In addition to applications such as cleaning of ceilings and walls, the booklet describes the cleaning of industrial equipment such as boiler tubes and filter screens. *The Spencer Turbine Co., Hartford 6, Conn.*

"BURNING BITUMINOUS COAL THE MODERN WAY," a 24-page booklet, presents numerous actual case histories from industries of all sizes and types. Engineering survey results and solutions, as well as such equipment as boilers, stokers, coal and ash handling units, and automatic controls, are described for each installation. Annual fuel consumption and operating costs also are discussed. *Bituminous Coal Institute, Southern Bldg., Washington 5, D. C.*



GAS TURBINES—Twelve factors to be considered in selecting a combustion gas turbine power plant for mechanical drive service are listed in 24-page booklet B-5859. Construction and design features, load diagrams, dimensioned outline drawings, and performance curves for four types of turbines are featured. Sample calculations aid in using the curves. Design details of component parts also are presented. *Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.*

CENTRIFUGAL BLOWERS — Design and performance features of multistage centrifugal blowers and exhausters for pressures from 1 to 9 psi and vacuum from 2 to 12 in. of mercury are appraised in 2-page data sheet A-932. Industrial applications are listed, including several on which savings can be made by

Personal copies of booklets can be obtained by writing directly to the manufacturers.

replacing compressed air formerly considered necessary. Typical performance and check lists of data required for blower or exhauster specifications are provided. *Air Appliance Div., U. S. Hoffman Machinery Corp., 105 Fourth Ave., New York 3, N. Y.*

MAGNETIC SWITCHES for across-the-line starting of single-phase and poly-phase squirrel cage motors in sizes up to 400 hp, 600 v a-c, are the subject of 12-page bulletin 504. Application, construction, safety features, modifications, and accessories are discussed. Tables list dimensions and weights for various types. *Federal Electric Products Co., 50 Paris St., Newark, N. J.*

VERTICAL TURBINE PUMPS and their characteristics are briefly described in 12-page bulletin W-450-B41. To point out the diversified applications for this type of pump, the booklet presents case histories of its use in deep wells, to move water from surface sources, for recirculating cooling water, condensate return, booster service, fire prevention, and many other applications. *Worthington Corp., Harrison, N. J.*

NEW FRAME DIMENSIONS for a-c motors from 1 to 30 hp, as established by new motor standards passed by NEMA on May 19, are presented in 8-page bulletin GEA-5995. The publication compares the old with the new frame assignments for open-type poly-phase, single-phase, and wound-rotor motors, as well as totally-enclosed, fan-cooled types. Also listed are suggested new frame assignments for foot-mounted and flange-mounted motors, and standards of minimum locked-rotor torque for general purpose single-phase motors. *General Electric Co., Schenectady 5.*

INDUSTRIAL CONTROLS—Non-indicating electric, electronic, and pneumatic controllers for temperature, pressure, and humidity, are evaluated in 84-page catalog 8305. Such equipment as pneumatic and electric valves, switches, and relays also are described. General discussions are presented on applications for industrial controls and automatic control systems. The booklet also contains engineering information such as specifications and application data. *Industrial Div., Minneapolis-Honeywell Regulator Co., Wayne and Windrim Ave., Philadelphia 44, Pa.*

DISTRIBUTION TRANSFORMER trends are discussed in a 24-page booklet "Trends of the Times," B-5856. A composite look at what power companies have done in their expansion

(Continued on page 72)

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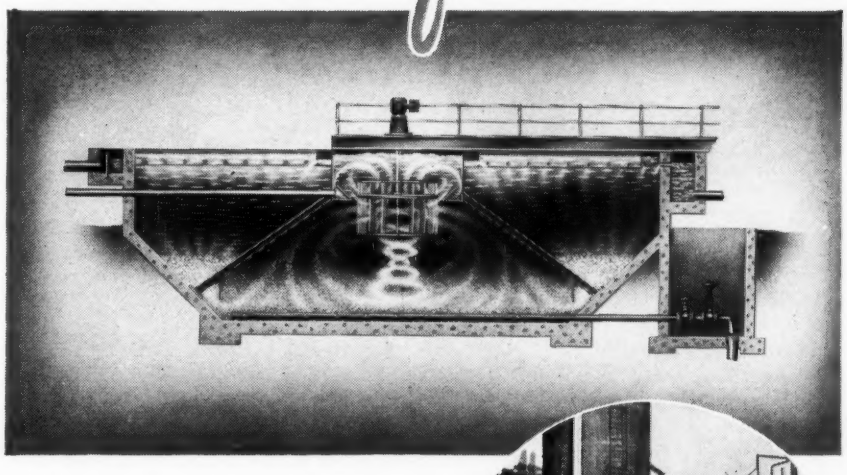

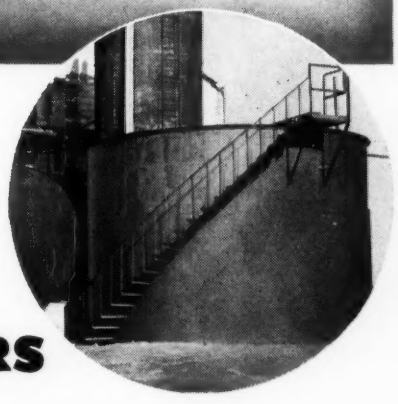

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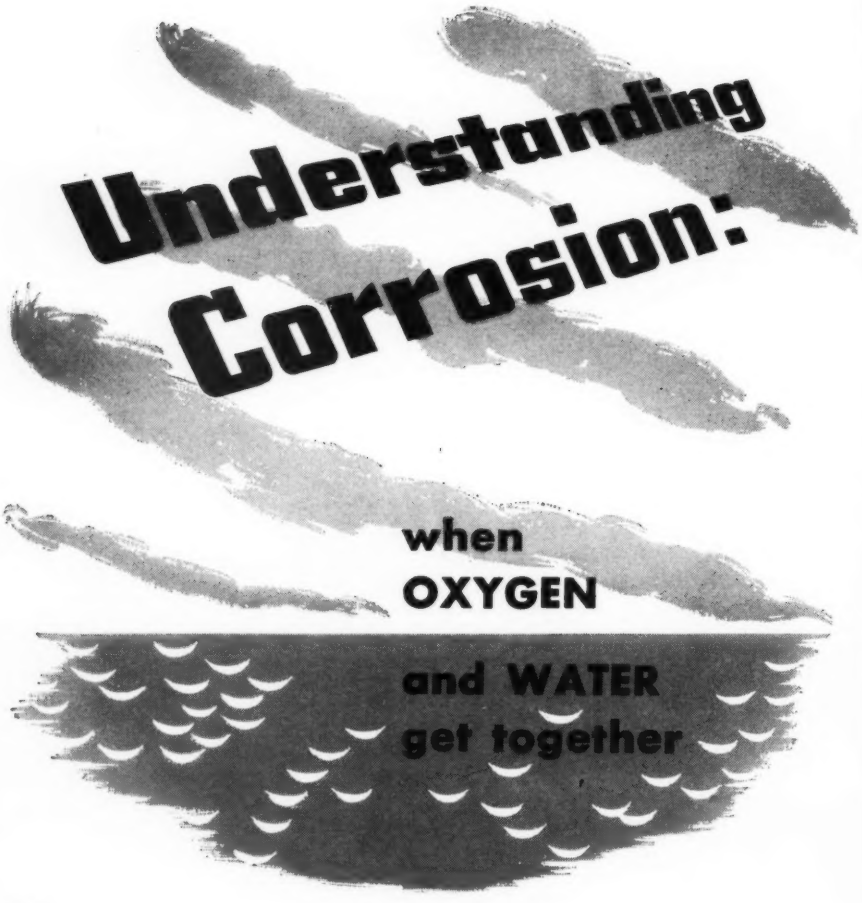

When free oxygen combines with atmospheric moisture or natural waters, the stage is well set for corrosive action. Controlling the degree and extent of that action are many related factors, variable in influence under differing circumstances.

The rate at which oxygen is transferred from atmosphere to a solution is, for example, directly proportional to the amount of exposed surface area of that solution, while the corrosion rate of immersed metal is, in turn, proportional to the oxygen concentration of the solution. Therefore, with all other factors stabilized, a reduction in exposed surface area will slow the oxygen-solution process, thereby greatly retarding corrosion.

How deeply metal is immersed, particularly in a quiet solution, is another determinant of corrosive action in which dissolved oxygen is the governing factor. Oxygen saturation, highest at and near the surface, diminishes with increasing depth as convection currents become less active. Corrosion at and immediately below the surface of a liquid is therefore far more severe than that encountered at greater depths.

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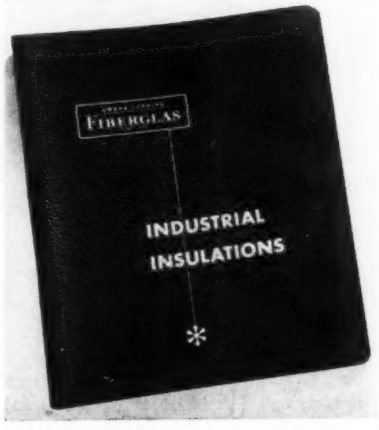
BOOKLETS —Starts on page 70

programs includes data on the increasing use of higher voltages, underground distribution systems, three-phase transformers, secondary banking, direct pole mounting, solid grounding, and transformer replacement. Related equipment is described. *Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30.*

TUBULAR MATERIALS—Stress rupture data on a number of chromium alloy tubing steels and other materials designed for high temperature service are tabulated on data card TDC-153. Tests are described as overloaded creep tests which are continued to actual failure of the specimen. The data offers an important means of evaluating the characteristics of metals for operation under stress at high temperature over long periods of time. *The Tubular Products Div., The Babcock & Wilcox Co., Beaver Falls, Pa.*



INDUSTRIAL INSULATIONS, including fibrous glass insulation products and hydrous calcium silicate heat insulations, are the subject of an 84-page book. Fibrous glass products include insulations for pipe, equipment, duct, and low temperature applications. Heat insulations include products for use at temperatures from below zero to 1200 F. Properties, uses, forms and sizes, coverings and accessories, engineering data, application specifications, and ordering information are discussed. *Owens-Corning Fiberglas Corp., Toledo 1, Ohio.*

DUCTILE CAST IRONS — Booklet 8-101, 12 pages, has been prepared to acquaint engineers with the unusual characteristics of ductile cast irons. In addition to telling what they are and why they are ductile, tables list physical properties and specific characteristics. Typical applications are given. *American Brake Shoe Co., Dept. A, 230 Park Ave., New York 17.*

consulting engineers' calendar

Date	Sponsor	Event	Location
Sept. 21-25	Industrial Inst. & Regulator Division American Society of Mechanical Engineers	Exhibit and Conference	Sherman Hotel Chicago, Illinois
Sept. 28-30	National Electronics Conference	9th General Conference	Sherman Hotel Chicago, Illinois
Sept. 28-30	American Society of Mechanical Engineers	Petroleum-Mech. Eng'r Conf.	Rice Hotel Houston, Texas
Oct. 5-7	American Society of Mechanical Engineers	Fall Meeting	Sheraton Hotel Rochester, N. Y.
Oct. 6-8	Elec. League of Western Penn.	4th Industrial Elec. Expo.	William Penn Hotel Pittsburgh, Pa.
Oct. 6-8	American Institute of Electrical Engineers	Fractional HP Motor Conf.	Hotel Keenan Ft. Wayne, Ind.
Oct. 8-9	Illinois Institute of Technology	Conf. on Ind'l Hydraulics	Sherman Hotel Chicago, Ill.
Oct. 17-20	Conveyor Equipment Mfrs. Assoc.	Annual Meeting	Greenbrier, White Sulfur Springs, W. Va.
Oct. 19-23	American Society of Civil Engineers	Annual Meeting	Statler Hotel New York, N. Y.
Oct. 19-23	National Safety Council	National Safety Congress	Conrad Hilton Hotel Chicago, Ill.
Oct. 23-24	Armour Research Foundation	Nation Noise Abatement Symposium	Ill. Inst. of Tech. Chicago, Ill.
Oct. 27	Consulting Chemist and Chem. Eng'rs.	25th Anniversary Meeting	Belmont Plaza Hotel New York, N. Y.
Oct. 28-30	American Management Association	Manufacturing Conference	Belevue-Stratford Philadelphia, Pa.
Nov. 2-6	American Institute of Electrical Engineers	Fall General Meeting	Hotel Muehlebach Kansas City, Mo.
Nov. 4-6	Industrial Management Society	Time and Motion Study and Management Clinic	Sheraton Hotel Chicago, Ill.
Nov. 9-12	Refrig. Equip. Mfrs. Assoc.	Refrig. & Air Cond. Exp.	Public Auditorium Cleveland, Ohio
Nov. 29-Dec. 4	American Society of Mechanical Engineers	Annual Meeting	Statler Hotel New York, N. Y.
Nov. 30-Dec. 5	Exposition of Chemical Industries	Exhibit	Commercial Museum Philadelphia, Pa.
Dec. 13-16	American Institute of Chemical Engineers	Annual Meeting	Jefferson Hotel St. Louis, Mo.

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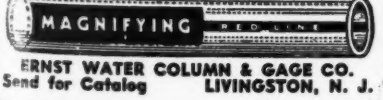

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This thoroughgoing analysis of the modern gas turbine gives you design information . . . operating characteristics . . . and industrial scope and uses of this new source of power. It explains the basic principles of various types of gas turbines and provides a careful coverage of the thermodynamics necessary to an understanding of the subject. You get detailed material on fuels, types of compressors, stresses and strains, the metals used, and the metallurgy involved in the design of efficient, economical power units.

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For engineers who wish a thorough, up-to-date look at the field, this book is recommended.

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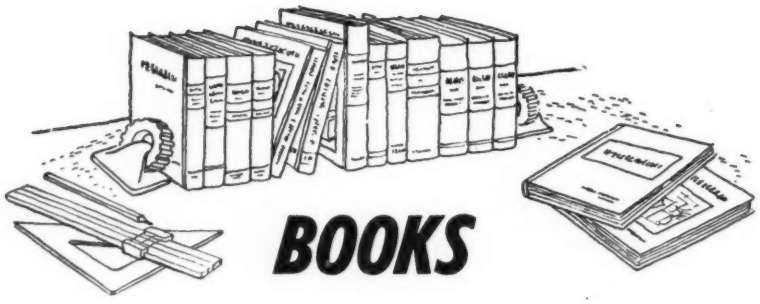

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TECHNIQUES OF PLANT MAINTENANCE AND ENGINEERING, 1953, Proceedings of the 4th Plant Maintenance Show, Cleveland, Ohio, 1953; Clapp and Poliak, Inc., 288 pages, $6.00.

Reviewed by Dan McConnell
Chief Engineer
Cone Mills Corporation

The plant maintenance and engineering conferences of past years have brought out much good data on this specialized field of engineering work. There has been constant improvement in the reporting of these conferences, and 1953 was a banner year from the standpoint of subjects covered and quality of reporting.

In this book the best part of the conference—the give and take of discussion—is thoroughly reported, and the book gives you something that can best be described as a chance for you to visit in your reading time with some of the best and most active men in the plant engineering and maintenance end of plants of all sizes. All of us like to know how the other man does things, and in this book those who presented papers spoke very freely, and in the give and take of discussion they spoke as openly.

If you are faced with a problem of setting up or modifying a maintenance system, many and various types are laid out for you in this work. If you feel your maintenance setup needs some reorganizing and you would like to take a two weeks trip through some neighboring plants to see how they do it, you can take the trip in your easy chair by the reading route. There are sections on how to work with other staff groups in the company—industrial engineering, accounting, purchasing, and labor relations. There are specific comments on many details that are the little things that make or cure headaches.

A consulting engineer working in the industrial field can get an insight into maintenance problems from this book, and the maintenance and plant engineers can find ammunition to use on their own operation.

The indexing is done about as well as can be done with a book of this kind, where so much information is developed in discussion, but it is suggested that this be treated as a book to be read through and marked for future reference.

Unless your plant engineering and maintenance setup approaches perfection, unless you never get snarled up in your paper work, and unless your machinery and buildings are good enough to last for fifty years, you will probably find information here worth the purchase price.

CHEMICAL PROCESS MACHINERY (Second Edition), by Emil R. Riegel, Reinhold Publishing Corporation, 718 pages, $12.50.

Reviewed by Thomas P. Hughes
Department of Engineering
University of Virginia

Americans justifiably take pride in recounting the wealth of their technology, but like Texans they often forget the assets which fail to stagger the imagination. In the class of essential but colorless wealth is the great body of technical literature devoted to the organization, classification, and comparison of factual data. Without the assistance of this material, engineers would consume countless man hours making decisions which can be had with a flip of a page. This is one of the secrets of American "know-how."

Emil Riegel's new edition of his literary showcase of equipment for

the chemical industry is up to date, broad in scope, and ready for reference. Couched in simple language and organized for clarity, this book can serve as a useful guide for the engineer who wants to know quickly what equipment is available to do the job. In essence, the data from the voluminous sales literature of the manufacturer has been analyzed and organized, and this is no mean feat or insignificant service.

The author has no intention of giving the last word before the plant is purchased or the machinery ordered. He asks the prospective purchaser to rely for his final decision upon the engineering staff of the manufacturer or the consulting engineer. Dr. Riegel is, wisely, not sticking his book out.

ALSO AVAILABLE

RECOMMENDED PRACTICE FOR SUPPLEMENTARY LIGHTING; Illuminating Engineering Society, 16 pages, 50¢. This publication is to be used with the recently released *Industrial Lighting Standard*. The new report provides additional information for supplementary lighting for critical seeing tasks. It was prepared by the I.E.S. Subcommittee on Supplementary Lighting to give the answers to many extraordinary lighting problems.

The new recommended practice is concerned primarily with lighting which supplements general illumination in manufacturing processes. The booklet is extremely well illustrated, having many apt photographs ideally pointing out the recommendations for each class of lighting difficulty.

HANDBOOK OF NOISE MEASUREMENT; Arnold P. G. Peterson and Leo L. Beranek; General Radio Company; 120 pages, including 18 page catalog section. This new publication replaces the familiar General Radio *Noise Primer*; it covers thoroughly the measurement of airborne sounds, including definitions, standards, measuring equipment, procedures, and interpretation of results.

NON-AQUEOUS SOLVENTS, by L. F. Audrieth and J. Kleinberg, John Wiley & Sons, $6.50. Describes non-aqueous solvents; also goes into concepts and theories of solvents, acids, bases, and associated chemicals. It discusses reactions and offers a number of useful tables.

APPLIED ELECTRICITY—Second Edition, by H. Cotton, The Industrial Press, 482 pages, $4.50. Covers the theory of magnetism, electrostatics, and electromagnetism. It discusses theoretical and practical aspects of many types of electrical equipment. A comprehensive account of the meter-kilogram-second system of units is included in this edition.

WELDABILITY OF STEELS, by Robert D. Stout and W. D'Orville Doty, Welding Research Council, 381 pages, $6.50.

The weldability of carbon and low alloy steels is one of the most interesting of engineering problems. During the past fifteen years, it has engaged the attention of many investigators whose laboratories have provided considerable information. A little of this information had previously been gathered together for over-all analysis and interpretation.

The Welding Research Council commissioned the authors to prepare a critical analysis and digest of this material—a job which they have done well.

The early chapters cover the fundamentals of the subject in relation to weldability. Next comes consideration of the basic factors which influence weldability of carbon and low alloy steels, after which are presented suggested methods for welding commonly used steels. The remaining chapters contain a review and evaluation of weldability tests and general conclusions. The Appendix provides 50 pages of tables on standard specification steels, listing them in three categories: those which are readily weldable, those in which some precautions are needed, and those which require special consideration. Welding procedures are indicated for each thickness of steel.

INDUSTRIAL FILMS

"Resistance Welding of Stainless Steel," 16 mm, sound and color, 22 minutes, Allegheny Ludlum Steel Corp., 2020 Oliver Building, Pittsburgh 22, Pa. This new motion picture discusses spot welding, seam welding, projection welding, and butt welding. It makes use of animation and drawings to clarify the regular photographed material.

"Forging in Closed Dies," 16 mm, sound and color, 33 minutes. Drop Forging Association, 605 Hanna Bldg., Cleveland 15, Ohio. This motion picture is an introduction to the closed die forging process. Steam and air lift hammers, board hammers, and mechanical and hydraulic forging presses are shown in action. A typical die room is pictured with a complete story about the cutting and preparation of the die. Heat treating and cleaning operations are also described.

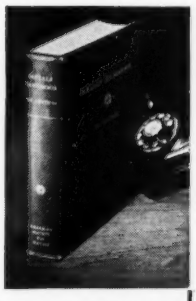
"Going Places," 16 mm, sound and color, General Electric Company, Schenectady, New York. Designed to show the public that moving people, not moving vehicles, is the key to solving the problem of traffic congestion. This film has been appearing on the Better Living TV Theater program throughout the country. It illustrates the need for good urban transit and is designed to stimulate public action.

"Electric Wiring With Alcoa Aluminum," Aluminum Company of America, Motion Pictures Division, 818 Alcoa Bldg., Pittsburgh 19, Pa. Originally prepared for electricians working on the erection of Alcoa's new Pittsburgh office building, this film deals almost entirely with techniques of handling and joining in installing aluminum conduit, cable, and wire. The compounds used and the preparation methods for joining wire and cable are fully explained. Accompanying the film is a booklet entitled "Electrical Wiring With Alcoa Aluminum."

"Underwater Giant," 16 mm, sound and color, 25 minutes. The Okonite Co., Passaic, N. J. Shows the manufacture, shipment and installation of world's largest high voltage rubber-insulated submarine cable—a single 7½-mile length, shipped in 9 cars and installed in Puget Sound.

"A Is for Atom," sound and color. General Electric Co., Schenectady 5, N. Y. An expanded 16-minute version now offered to business and industry, of the 10-minute film being shown in movie houses throughout the country. Copies loaned by G-E district offices, or sold at $100 per print.

The Metals Handbook



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